AERONAUTICAL ENGINEERING REVIEW

SEPTEMBER 1949


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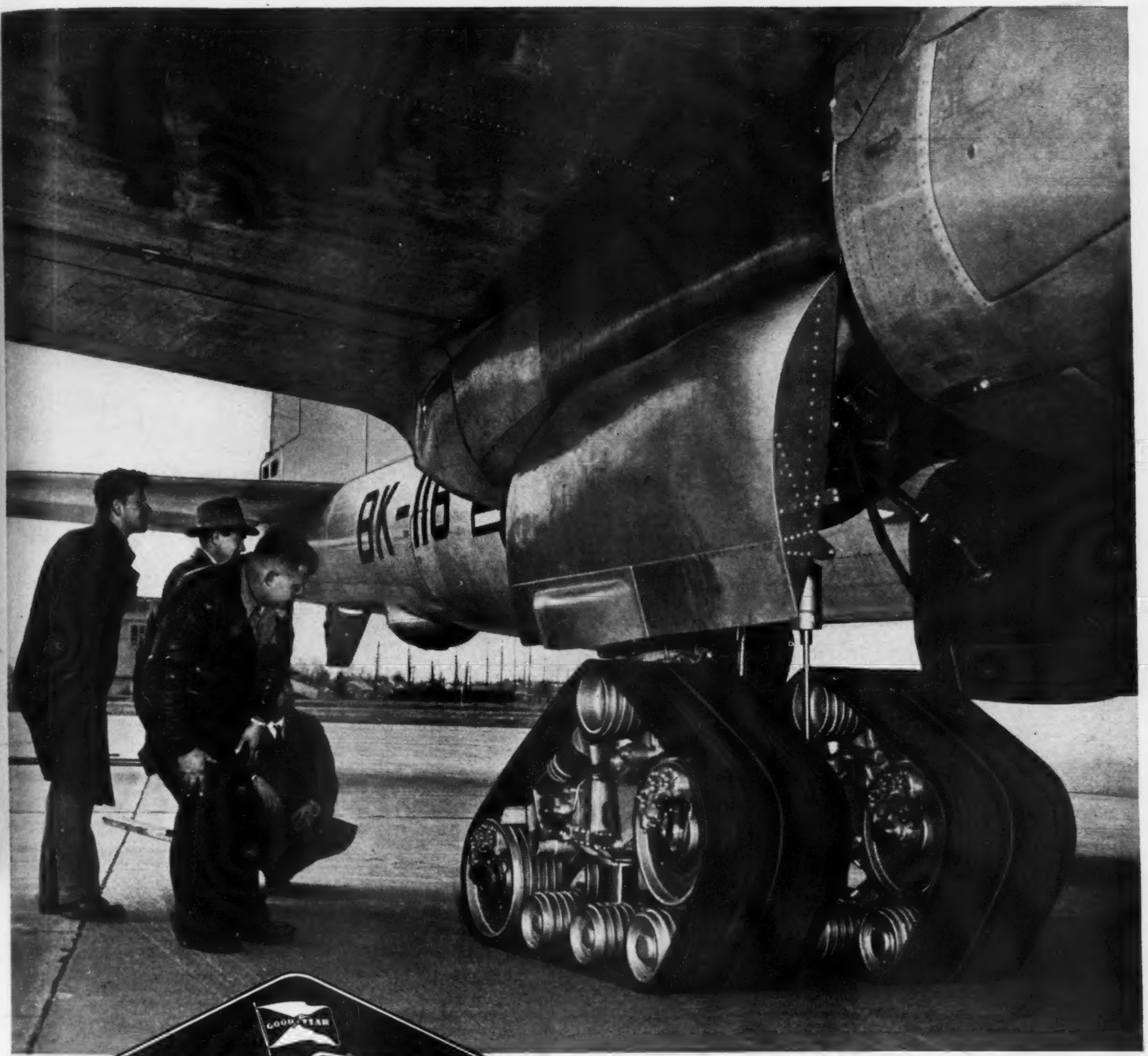
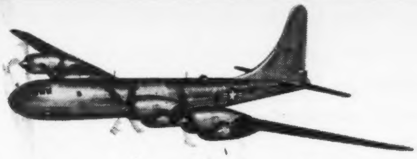


GOODYEAR
AVIATION PRODUCTS



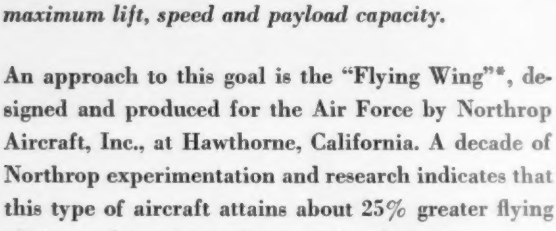
Now a rubber runway for the B-50

To solve the problem of handling the giant B-50 Boeing Superfortress on unimproved fields, Goodyear, in cooperation with Boeing engineers, has developed a radically new retractable landing gear — the world's first track-tread landing gear for a heavy four-engine bomber. This unique gear multiplies the practical operating field of giant planes because it increases the footprint area three times that of the conventional landing gear of the B-50. Interesting design features include the use of endless rubber belts, reinforced with steel cable, running over a series of floating bogies controlled by a battery of four Goodyear Single Disc Brakes on each main track — *the entire assembly furnished by Goodyear!* This revolutionary landing gear for giant bombers is another of the many Goodyear-built products which have spurred aviation progress for the past forty years.

Goodyear, Aviation Products Division
Akron 16, Ohio or Los Angeles 54, California

MORE AIRCRAFT LAND ON GOODYEAR TIRES, TUBES, WHEELS AND BRAKES THAN ON ANY OTHER KIND


SPANS U.S. in 4½ HOURS



AERONAUTICAL ENGINEERING REVIEW

Vol. 8 SEPTEMBER, 1949 No. 9

Cover—Annual Summer Meeting, Los Angeles, Calif.

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Articles

Reviews

Published Monthly by the Institute of the Aeronautical Sciences, Inc.

NEW SUPER DC-3 CUTS COSTS AND GROUND DELAYS!

Here's the fastest commercial transport to load and unload—both passengers and baggage—ever designed. It's the new Douglas *Super* DC-3!

No loading ramp needed! Built-in ramp lowers seconds after plane halts. Passengers carry their own wraps and luggage on and off. All luggage easily and quickly stored in big cabin racks.

Large rear baggage and cargo space (5′ x 14′ or 513 cubic feet) is quickly convertible to extra seats. New up-swing door and waist-high loading platform speed baggage handling.

Available now to serve cities large or small, the *Super* DC-3 makes possible substantial savings in initial cost . . . operations . . . and maintenance. For economical, *dependable* service, get the facts now on the new 250-mph *Super* DC-3.

DOUGLAS AIRCRAFT COMPANY, INC.
SANTA MONICA, CALIFORNIA

Large Cabin Luggage Racks speed ground time by enabling passengers to carry wraps and luggage directly on and off the *Super* DC-3. Built-in stair ramp ready seconds after arrival.

513 Cubic Feet of space in the large rear convertible baggage space, and wide up-swing door, makes the *Super* DC-3 one of the most versatile of all modern air transports.

DOUGLAS

Super DC-3

I.A.S. News

A Record of People and Events of Interest to Institute Members

Bane and Chanute Awards Presented to Air Force and Navy Pilots

Capt. Harold W. Robbins, U.S.A.F., and Capt. Frederick M. Trapnell, U.S.N., Receive I.A.S. Honors at Dinner Held in Los Angeles on July 22, at Close of Annual Summer Meeting

The Octave Chanute Award for 1949

Captain Frederick M. Trapnell, Coordinator of Tests, Naval Air Test Center, Patuxent River, Md., has received The Octave Chanute Award for 1949 "for his contributions to flight testing of experimental aircraft with particular reference to operating requirements for carrier-based, jet-propelled airplanes."

Since June, 1946, Captain Trapnell has been responsible for the prosecution of the aviation test program of the Bureau of Aeronautics and has reviewed all projects under study and test at Patuxent. He has demonstrated an outstanding ability not only in flying all types of aircraft but also in detecting critical deficiencies in new airplanes after only one or two brief flights and in suggesting improvements that will remove these deficiencies. Through him, a highly efficient test organization has been evolved at Patuxent which is developing many new techniques and new methods for the scientific analysis of flight-test data.

Capt. Frederick M. Trapnell, U.S.N.

▶ **Tested Carrier Jets**—During World War II, the Navy was faced with the extremely serious problem of operating jet aircraft from aircraft carriers. Captain Trapnell, on his own initiative, proposed and undertook an accelerated evaluation program in which he personally flew every available new aircraft. He also made positive technical recommendations so thorough and complete that the boundaries of this major problem were completely defined. By his individual effort he tremendously expedited the use of jet-propelled aircraft on aircraft carriers.

▶ **Varied Naval Career**—Captain Trapnell was born in Elizabeth, N.J., in 1902. He was graduated from the U.S. Naval Academy at Annapolis in 1923 and received his wings in 1927 after flight training at Pensacola. In 1930 he assumed flight-test duties at the Anacostia Naval Air Station and remained there until he was ordered to duty in July, 1932, as a member of the heavier-than-air unit with the dirigibles "Akron" and "Macon." Here he was responsible for the development of equipment, procedures, and techniques for "hooking-in" airplanes to airships. After 6 years of patrol squadron duty, he was again ordered to flight test at Anacostia, where he served for 3 years. He commanded the escort carrier U.S.S. "Breton" from November, 1943, to October, 1944, when he was assigned as Chief of Staff to Command of Fast Carrier Task Group in operations against Japan. Captain Trapnell was also on special duty for 6 months with the U.S. Strategic Bombing Survey. He has received the Legion of Merit and the Bronze Star Medal and was commended in 1943 by the Secretary of the Navy for his flight-test work.

Presentation of The Octave Chanute Award to Captain Trapnell marks the eleventh year that it has been conferred "for a notable contribution made by a pilot to the aeronautical sciences." The Chanute Award was established by the I.A.S. in 1939 to honor the memory of Octave Chanute, whose glider experiments, writings, and personal help provided

Capt. Harold W. Robbins, U.S.A.F.

inspiration and encouragement for the Wright brothers.

The Thurman H. Bane Award for 1949

Captain Harold W. Robbins, of the U.S.A.F. Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, has been awarded The Thurman H. Bane Award for 1949. The award, which is presented each year "to an officer or civilian of the Air Materiel Command for an outstanding achievement in aeronautical development," cited Captain Robbins' "contribution to the development of jet-assisted take-off for cargo aircraft."

▶ **Directed JATO Research**—The successful use of JATO in the rescue of the twelve airmen from a Greenland ice cap last December was made possible through the results of a year of specific development and application work within the Engineering Division of the Air Materiel Command under the direction of Capt. Harold W. Robbins, of the Power Plant Laboratory. The Greenland rescue was made by the Air Sea Rescue Service with a U.S.A.F. C-47 cargo plane outfitted with JATO units and skis at the A.M.C., Wright-Patterson Air Force Base. Some of the JATO problems solved successfully by Captain Robbins were the fabrication and installation of attachment fittings to aircraft structures already under critical stress conditions, the provision of temperature protection to exposed aircraft components, and the provision of safe pilot controls for actuating and jettisoning the assist take-off motors.

▶ **Flew 37 Missions in World War II**—Captain Robbins was born in Independence, Va., and was graduated from Ohio State University in 1937 with the Degree of Bachelor of Mechanical Engineering. He entered the Air Force in July, 1941. He flew on 37 missions in the C.B.I. Theatre during World War II and was awarded the Purple Heart and the Air Medal. His present assignment to the Air Materiel Command was made in February, 1945. He has also been connected with the General Electric Company in Philadelphia. Captain Robbins is 33 years of age, is married, and has a 14-month old son.

The Thurman H. Bane Award was established by Major Reuben H. Fleet, who was President of the I.A.S. in 1944, and is awarded yearly. It honors the memory of the late Col. Thurman H. Bane, former Commanding Officer of McCook Field, Dayton, Ohio, which was the first headquarters for the Army's aeronautical research and development and is now Wright-Patterson Air Force Base, the site of the test and research facilities of the U.S.A.F. Air Materiel Command.

National Meetings Calendar

Dec. 17	Wright Brothers Lecture, Washington, D.C.
Jan. 23-26, 1950	Eighteenth Annual Meeting, New York.

For details see page 96

25,000-Mile Airplane Range Northrop Research Goal

Engineers at Northrop Aircraft are carrying out research in boundary-layer control under the guidance of Dr. Werner Pfenninger, M.I.A.S., one of the world's foremost authorities on the subject.

▶ **Began Work in Zurich**—Dr. Pfenninger, who was brought to this country by Northrop in January, 1949, attained prominence for his work in boundary-layer control at the Institute for Aerodynamics of the Federal Institute of Technology at Zurich, Switzerland. He began this research in 1941.

The Swiss Study Commission for Aeronautics, whose interest was aroused by Dr. Pfenninger's early calculations, financed him in actual wind-tunnel experiments with airfoils employing suction slots. After painstaking tests he discovered that the drag of certain airfoils could be reduced more than 50 per cent, pointing toward great savings in fuel consumption.

Although results of the Zurich tests cannot be arbitrarily assumed to apply in the same way on an actual plane, because of turbulence in the wind tunnel and the necessity for testing at comparatively low speeds, Dr. Pfenninger believes the advantages to be gained by this boundary-layer control are enormous, particularly on the B-49 Flying Wing.

▶ **Require One-Fourth Power**—An airplane like Northrop's 213,000-lb. Flying Wing, the scientist pointed out, uses eight jet engines to carry it along at its 500-m.p.h. clip, the engines developing 32,000 lbs. thrust at sea level.

By use of full boundary-layer control, the Wing could carry the same load at the same speed with as much power as is supplied by only two of the jet engines. Included in this sharply reduced engine requirement is the power needed to drive the suction pump, Dr. Pfenninger asserted.

Boundary-layer air would be whisked off the surface of the Flying Wing at rate of about 3,000 cu.ft. per sec., and the blast that would be exhausted from a tailpipe would contribute an added "push" to the plane.

Because of its efficient all-wing construction, Northrop engineers say that it would be possible to install boundary-layer control slots over virtually the entire surface of the B-49, whereas on the orthodox airplane the fuselage and tail surfaces present much more complex problems. They estimate that the Flying Wing, driven by gas turbines or compound piston engines and incorporating boundary-layer control, could travel nonstop for about 25,000 miles without refueling.

Northrop's research has been sponsored and financed by the company itself and is to date confined to basic calculations, supported by data that Dr. Pfenninger obtained from his Zurich tests.

R.Ae.S. Issues New Quarterly Periodical

The Royal Aeronautical Society has initiated a new periodical, *The Aeronautical Quarterly*, in order to give more rapid and widespread distribution of the results of the scientific research that is being carried on in industrial, university, and governmental laboratories. The R.Ae.S. hopes that research workers will have the results of their investigations more widely recognized and applied and that they will take encouragement and stimulation from the publication, in easily obtainable form, of the results of their endeavors. *The Aeronautical Quarterly* will contain papers describing new and original work and articles reviewing progress in some specialized field of activity. Leading authorities pass on all papers submitted. The R.Ae.S. *Journal*, which publishes lectures read before the Society and original papers, is being continued on its usual monthly basis.

▶ **Contains Seven Papers**—The first issue, Volume 1, Part 1, dated May, 1949, is 122 pages in length and resembles the R.Ae.S. *Journal* in size and mechanical composition. It contains seven papers, as follows:

"Control Reversal Effects on Swept-Back Wings," H. Templeton. "Calculation of Downwash Behind a Supersonic Wing," G. N. Ward. "Estimation of the Effect of a Parameter Change on the Roots of Stability Equations," K. Mitchell. "Flutter of Systems With Many Freedoms," W. J. Duncan. "Note on Propeller-Turbine Reduction Methods," E. C. Pike. "Determination of the Drag of Jet-Propelled Aircraft in Flight," G. W. Trevelyan and D. R. Blundell. "Notes on the Linear Theory of Incompressible Flow Around Symmetrical Swept-Back Wings at Zero Lift," F. Ursell.

▸ **Editorial Board**—Members are: W. G. A. Perring (Chairman), Dr. H. Roxbee Cox, Prof. S. Goldstein, Sir Richard Southwell, G. H. Dowty, and J. Smith. Editorial Executives are: Capt. J. Laurence Pritchard, Mrs. Joan Bradbrooke, and Dr. D. M. A. Leggett.

Single copies are priced at 10*s.* net. R.Ae.S. members may obtain copies at 7*s.* 6*d.* net each. Orders should be sent to The Royal Aeronautical Society, 4 Hamilton Place, Piccadilly, London, W.1, England.

Burden Organizes Investment Firm

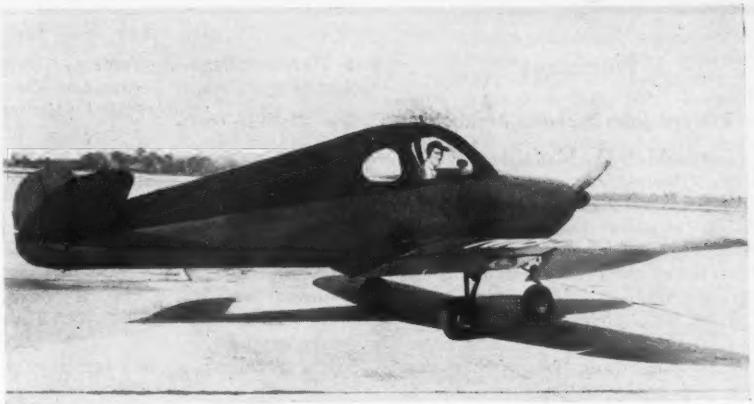
William A. M. Burden, President of the Institute, has formed a limited partnership firm, William A. M. Burden & Company, it was announced earlier this summer. Company was organized to invest its own capital.

General partners in the new firm are Mr. Burden's brother, Shirley C. Burden, and R. McLean Stewart, President of South American Mines Company, and other mining enterprises.

New Contender in Personal Plane Market

C. M. Jamieson, M.I.A.S., former Chief Engineer at Culver Aircraft for the prewar Cadet and postwar Design Engineer on the Beechcraft Bonanza, who quietly formed his own firm, Jamieson Aircraft Company, De Land, Fla., is entering the personal plane market with a new three-place, all-metal monoplane with retractable tricycle landing gear which has undergone accelerated flight tests the past few months.

▸ **Cruises at 150**—The Jupiter is powered by a Lycoming 0-235-Cl, 115-hp. engine, has a cruising speed of more than 150 m.p.h., and has a landing speed guaranteed to be "under 40 m.p.h." The plane, however, has been flown under approximately 80 per cent gross load at less than 30 m.p.h. for a period of several minutes, Jamieson says, without losing altitude.



'Jupiter by Jamieson': *Engineered by C. M. Jamieson, who was Design Engineer on the Beech Bonanza before forming his own Jamieson Aircraft Company, DeLand, Fla., new personal plane, Jupiter, is selling at a guaranteed F.A.F. price of $2,500 with fuel and oil tanks full. Says company: "We are not fooling on the price and have already committed ourselves to make deliveries at this figure." Ten planes were to be delivered before end of July and production is to be accelerated to 40–50 a month in 3 to 5 months. Ross M. Holdeman, Sales Manager, says company is in position to make delivery within 90 days after receipt of concrete order.*

The new plane has also been consistently breaking ground in under 100 ft. with an initial climb of more than 1,050 ft. per min. Landings have been made under 30 m.p.h. under no wind conditions with no flaps and a landing roll of less than 50 ft., company says. Jupiter has a "butterfly" tail configuration.

Overall length is 20 ft. 10 in.; overall height, 6 ft. 9 in.; wing span, 29 ft.; wheel tread, 6 ft. $2^1/_2$ in. Wing area, including ailerons and flaps, is 123.2 sq.ft.; aileron area total, 7.69 sq.ft.; flap area total, 27 sq.ft.; fixed tail surface area, 11.59 sq.ft.; movable tail surface area, 6.11 sq.ft.

Alvin P. Adams & Associates New Corporate Member

The aviation consulting firm of Alvin P. Adams & Associates has joined the Institute of the Aeronautical Sciences as a Corporate Member.

▸ **Specialized Reports**—The company undertakes specialized reports, surveys and analyses for managements of air lines, aviation manufacturing companies, Government agencies, and certain financial institutions.

Scope of activities includes the preparation of the Civil Aeronautics Board cases involving new routes, extensions, airport planning, aircraft evaluations, management analyses, mail pay requests, financial evaluations, investment analyses, merger evaluations, etc.

This type of work, says the company, generally speaking requires specialists not employed by many firms, in view of the limited use of their time that can be made. In addition, the outside, objective point of view, in many instances involving market surveys, for example, is impossible to obtain in the personnel of the company itself.

Alvin P. Adams & Associates is believed to be the oldest in its line of activities, having started in 1940.

Dayton Aircraft Products New I.A.S. Member

Dayton Aircraft Products, Inc., new Institute Corporate Member, concentrates its activity on experimental, developmental, and production contracts for the U.S. Air Force and Bureau of Aeronautics, Navy Department.

In many cases, Dayton Aircraft says, a program is taken on at its inception, including the design, building of prototypes, and service test models and then carried through the production phase. Aircraft accessories and components—such as bomb and rocket release mechanisms, maintenance stands and shelters, hydraulic wing tip and axle jacks, and specialized armament, ground, and electronic equipment—are typical of the work specialized in by the company.

▸ **World Patent Rights**—Dayton Aircraft has world patent rights on the approved Army-Navy type of antistatic antenna fittings and thereby supplies not only the Government but the leading air lines and aircraft manufacturers in the U.S. and abroad.

A nationwide dealer organization markets these products to the industry and civil aircraft operators.

Necrology

Edward John Nicholas Archbold

Edward J. N. Archbold, Aerodynamicist, Bristol Aeroplane Company Ltd., of Great Britain, was killed in a flying accident last May 6. Mr. Archbold, who became a Technical Member of the Institute in 1943, was 27 years old.

Born in London on January 8, 1922, he was educated in the University of London at the Northampton Polytechnic Institute, graduating in July, 1942, with the degree of B.Sc. (Engineering) in Aeronautical Engineering.

▶ **Handley Page Apprentice**—From September, 1938, to September, 1941, he had been a student apprentice at Handley Page Ltd., Cricklewood, London, working on detail fitting, subassembly, engine installation, test, and in the service department.

Later he undertook technical office training from September, 1941, to September, 1942, when he was named Technical Assistant at Handley Page. Subsequently, he was promoted to Aerodynamicist.

His technical apprenticeship was spent in actual work on production aircraft in the various shops and offices and not in a special apprentices school.

American Mathematical Society Publishes Proceedings

The American Mathematical Society is publishing the Proceedings of the First Symposium in Applied Mathematics which was held at Brown University in the summer of 1947.

Topic of this symposium, of which the I.A.S. was a sponsor, was "Nonlinear Problems in Mechanics of Continua."

Gifts to the Institute Collection

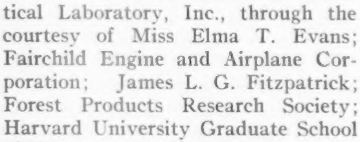
Eleven scrapbooks kept by Orville Wright, containing a record through newspapers of the activities of the Wright Brothers and writings about them, from 1902 to 1948, were received from the estate of Orville Wright.

Captain John Jay Ide gave more than 75 pieces of literature from the 18th Salon de l'Aeronautique, held in Paris from April 29 to May 15, 1949. Data were included on new Fouga, Morane-Saulnier and other French aircraft; Fokker, Vickers-Armstrongs and other European aircraft; Hispano-Suiza, Mathis, Potez, Salmson and other engines; French and British research activity; and Italian civil aviation.

A complete *Documentation Technique* of the Salon, describing in one volume all the exhibits, was sent by M. Vaysse, of The Union Syndicale des Industries Aéronautiques.

A model of the Wright 3350 Cyclone engine was sent by Guy W. Vaughan. Republic Aviation Corporation, through the courtesy of Mrs. George Burrell, gave 400 publications of the National Advisory Committee for Aeronautics.

Additional gifts were received from Aircraft Radio Corporation; American Airlines, Inc.; American Standards Association; British Joint Services Mission; Canadian National Research Council; Cornell Aeronautical Laboratory, Inc., through the courtesy of Miss Elma T. Evans; Fairchild Engine and Airplane Corporation; James L. G. Fitzpatrick; Forest Products Research Society; Harvard University Graduate School of Business Administration; International Nickel Company, Inc.; Mrs. Bella C. Landauer; Reynolds Metals Company; R. J. Schoonmaker; Taft-Peirce Manufacturing Company; Trilane Associates; Miss Pearl I. Young; and the U.S. Air Coordinating Committee, Air Materiel Command, Bureau of Mines, Central Air Documents Office, Civil Aeronautics Administration, Civil Aeronautics Board, Department of State, Foreign and Domestic Commerce Bureau, National Advisory Committee for Aeronautics, National Bureau of Standards, Congressional Committees on Appropriations, Armed Services, Atomic Energy and Expenditures in Executive Departments, and the House and Senate document rooms.



CHAIRMAN OF THE BOARD

Glenn L. Martin, H.F.I.A.S., was named Chairman of the Board of The Glenn L. Martin Company just 2 weeks prior to the 40th anniversary of his first flight at Santa Ana, Calif., August 1, 1909. Succeeding the veteran aircraft manufacturer as President and General Manager is C. C. Pearson, former Curtiss-Wright Vice-President.

I.A.S. Newslines

▶ New Assignment . . . **Brig. Gen. Harry G. Armstrong,** F.I.A.S., former Commandant of Air University School of Aviation Medicine, Randolph Field, Tex., has been assigned Acting Deputy Surgeon General, Hq., U.S.A.F., Washington 25, D.C.

▶ Nonskid Brake Device . . . **Wellwood E. Beall,** F.I.A.S., Boeing Vice-President for Engineering & Sales, announced Boeing has developed a brake attachment that automatically prevents skidding. New device has been operated successfully on a Boeing XB-47 and YC-97A. Electronically controlled valving unit, set in motion by operation of plane's normal hydraulic brake, keeps braking pressure below skidding point at all times, Mr. Beall said. Hydro-Aire Inc., Burbank, Calif., has been licensed to sell device commercially.

▶ Awarded Harmon Trophy . . . **Ralph S. Damon,** F.I.A.S., President of Trans World Airline, has been awarded International League of Aviators American national trophy in recognition of his service to aviation over past 31 years. Established in 1925 by late C. B. Harmon, pioneer balloonist and aeronaut, together with other internationally minded fliers, honor was set up as an annual award to airmen making outstanding contributions to science and industry of aviation.

▶ Gets Government Post . . . **James D. Redding,** A.F.I.A.S., Manager of the S.A.E. since 1941, has been appointed Executive Director of Committee on Aeronautics, Research & Development Board of National Military Establishment. Mr. Redding goes to the Government post at the direct request of Dr. Karl T. Compton, F.I.A.S., Research & Development Board chairman.

Corporate Member News

• New Recording Instrument . . . **Airborne Instruments Laboratory, Inc.,** Mineola, N.Y., is producing a new recording instrument used primarily in determining directional characteristics of radar antennas. System can also be used to record light intensities, sound pressures, and heat levels at writing rates higher than formerly available.

• Aircraft Temperature Control by Electronics . . . Accurate and rapid regulation of temperatures in aircraft cabins and fuel, oil, and anti-icing systems can be achieved with the Electronic Temperature Regulator announced by **AiResearch Manufacturing Company.** In controlling aircraft cabin temperature, the electrical signals received from sensitive temperature pickups located in the mixing duct, the cabin, and an ambient air duct are converted into proper command signals for electrically actuated hot and cold air-intake valves. Operation of the regulator is based upon the rate of temperature change. The device can be applied in the Boeing B-47, the North American F-86, and the Northrop F-89.

• First Flight This Month . . . Engineers of **Chase Aircraft Company, Inc.,** expect their C-123 cargo transport to be ready for initial flights in September. The C-123 is designed to accommodate a 155-mm. howitzer and one truck, 60 fully equipped troops, or 50 litter patients. It has a wing span of 110 ft. and a length of 77 ft.

• Steps Up Bomb-Drop Test . . . Aircraft Mechanic Willis D. McClure of **Consolidated Vultee Aircraft Corporation** won his company's thanks for a quick, easy, and cheap method of testing complex electrical wiring on B-36's bomb-dropping system. To make the test, men had to install bomb racks, turn on plane's electrical power system, operate bomb releases as they would be operated on a mission, and then remove bomb racks. McClure reasoned that, since the object of whole operation was to learn whether the circuits were properly hooked up, he could eliminate installation of racks and slings if he had a test box on which lights would flash to indicate proper circuit connections when bomb-dropping switches were thrown. The idea paid off when box completed test of bomb-dropping system in $1^1/_2$ hours. Old method of doing the same test would require over 200 hours . . . First of 36 T-29 "flying classrooms" ordered by Air Force for navigational training will be completed this month at San Diego plant of Convair. The T-29 is outwardly similar to Convair-Liner transport, with addition of four astrodomes atop the fuselage. Sixteen students plus crew of five will be accommodated.

• Net earnings of **Continental Motors Corporation** and consolidated subsidiaries for 6 months ended April 30, 1949, amounted to $1,319,414 or 40 cents per share on the 3,300,000 common outstanding. Sales for the period were $43,650,000 compared with $57,054,547 for the same period last year.

• 1,200-M.P.H. Air Jet Makes Shock Waves Visible . . . **Curtiss-Wright Corporation** has built a supersonic air jet at its Columbus Airplane Division plant for implementing basic airflow research. The company's power plant drives air through the 3-in. nozzle at the rate of 6,500 cu.ft. per min. Shock waves in the air can be readily seen when the jet is operating. This new jet supplants the use of high-speed wind tunnels for observation of flow around bodies.

• Improved Prop Synchronizer . . . Following more than a year of research and development by the **Propeller Division, Curtiss-Wright Corporation,** an improved Curtiss propeller synchronizer is now being specified for the latest type multiengined aircraft. Designed to meet requirements of both military and commercial applications, the improved r.p.m. synchronizer retains the features of presently installed Curtiss synchronizers which have proved successful over millions of hours of operation. Improved mechanism is incorporated in a completely enclosed standard radio-rack type metal case, held in a new shockproof mounting arrangement, which facilitates installation and servicing. When synchronizer is installed, it is necessary only to set cockpit control lever to take-off position and to slide unit into place. No other mechanical or electrical connections are necessary . . . Major Gen. Edward M. Powers, U.S.A.F. (ret.) has been appointed Vice-President and Director of Engineering for Curtiss-Wright. General Powers will coordinate the engineering activities of the Wright Aeronautical, Propeller and Airplane divisions of the company.

• Acquires Helioplane Rights . . . **Fairchild Engine and Airplane Corporation** has been licensed to use "helioplane" principles in designing military and commercial aircraft. Agreement with Helio Corporation of Norwood, Mass., grants Fairchild exclusive manufacturing rights and world-wide sales rights for helioplanes in the higher horsepower class designed for certain specialized military or commercial use. The helioplane was designed by Dr. Otto C. Koppen, F.I.A.S., Professor of Aeronautical Engineering at M.I.T., to specifications formulated by Dr. Lynn L. Bollinger, of Harvard Graduate School of Business Administration, a former air-line pilot. Professor Koppen succeeded in solving problems of slow flight control which have baffled engineers for years.

• G-E Pulse Counter . . . A new electronic "pulse counter" for accurate measurement of very high speeds has been announced by **General Electric's** Special Products Division. Designed for special applications that call for precision measurement over a wide range of rotating speeds, new tachometer was developed by company's General Engineering and Consulting Laboratory and Lynn (Mass.) Turbine Engineering Division. Equipment consists of high-frequency pulse generator or pick-up, an electronic counting circuit, and two speed-indicating units—one for on-the-spot readings and the other for remote reading.

• Smithsonian Exhibits Cross-Wind Landing Wheel . . . The Smithsonian Institution has installed a permanent display in the National Air Museum which features the cross-wind landing wheel developed by the **Goodyear Aircraft Corporation.** Photographs and a cutaway model show its design and how it compares with conventional wheels in making cross-wind landings.

FIVE-PLACE TWIN BONANZA PROJECTED

Beech Aircraft Corporation has announced that the Model 50 Beechcraft, shown here in artist's sketch, will be delivered sometime in early 1950 priced at approximately $30,000, complete. Designed primarily as a five-place two-engined airplane of conventional type, Beech says it can accommodate six people for short-range flights. Further details will be available after flight tests are completed.

ALL-WEATHER OPERATOR

New Lockheed F-94 on a test flight shows off revamped nose section containing radar equipment for 24-hour all-weather operations and afterburner installation giving extra speed and power. Pilot is in front; radar operator is in rear.

- New Jack & Heintz President . . . Frank R. Kohnstamm has been elected President and Chief Executive Officer, and Kenneth G. Donald, former President, has become Chairman of the Board, it has been announced by **Jack & Heintz Precision Industries, Inc.** Kohnstamm previously was Senior Vice-President, joining Jack & Heintz in 1947 after wide experience in the industrial field.

- New First for Connies . . . Constellation is reported by Hall L. Hibbard, **Lockheed Aircraft Corporation** Vice-President and Chief Engineer, to be first airplane to be made eligible for certification under the International Civil Aviation Organization standards. Papers certifying that the Connies have complied with all airworthiness standards adopted by the ICAO have been sent by C.A.A. to Dr. Albert Roper, Secretary General of the international regulatory body in Montreal, Canada . . . Deliveries and unfilled orders for the Constellation now total 208, largest number of transport aircraft of any type to be ordered since the war . . . Lockheed has begun design work on a Constellation that will accommodate over 90 passengers and will weigh more than 65 tons with full load. . . . President Robert E. Gross also announced inauguration of a news letter to keep 12,000 stockholders informed of company progress.

- All-Time Company Record . . . **United Air Lines** reports all-time company record for passenger and cargo traffic during first 6 months of the year. United flew an estimated million passengers and about 627,000,000 revenue passenger-miles, increases of 17 and 16 per cent, respectively, as compared with same period last year. In addition, United flew 10,900,000 air-freight ton-miles in the half year, an increase of $21^{1}/_{2}$ per cent over same period 1948; 5,300,000 mail ton-miles, up 30 per cent, and 2,850,000 express ton-miles, a decrease of $24^{1}/_{2}$ per cent.

- 4,000-Hp. Electric Motor Tests Rotors . . . A 48-ton, 12-ft.-high electric motor built by **Westinghouse Electric Corporation**, has been shipped to the U.S.A.F. A.M.C. at Wright-Patterson Air Force Base. Mounted on a 30-ft. steel tower, it will whirl experimental helicopter rotors well above ground-level turbulence.

- TV Now Tool for Jet Research . . . R.C.A., working with **Wright Aeronautical Corporation**, reports tests have shown the practicability of using remote television for evaluation of combustion efficiency of ram-jets. TV cameras equipped with infrared-sensitive pickup tubes have also been used successfully for quantitative detection of "hot spots" in metals at temperatures above 600°C. long before they become visible to the unaided eye. . . . Wright Aeronautical has recently received more than $4,500,000 in orders for Cyclone 18BD engines, which will be installed in Lockheed Constellation transports. Deliveries will begin this Fall, with most of the engines scheduled for production in the first half of 1950.

Meet Your Section Chairman

Elliott Gray Reid

San Francisco Section

A Founder Member of the Institute, Elliott G. Reid, who has been Professor of Aerodynamics at Stanford since 1927, says that his interest in aeronautics was kindled in 1910 when, as a small boy, he was taken to see Glenn Curtiss' then-phenomenal June Bug. Moreover, he still regards that primitive record-breaker as "one of the most fearful and wonderful contraptions I've ever seen."

Trained at the University of Michigan, he received the degree of B.S. in Aeronautical Engineering in 1922 and, having also satisfied the academic requirements for the M.S., was awarded that degree in 1923 upon completion of an experimental thesis investigation carried out while serving as a Junior Engineer on the N.A.C.A.'s Langley Field staff. In 1937, the professional degree of Aeronautical Engineer was conferred upon him by his Alma Mater.

▶ **Collaborated with Fred Weick**—While at Langley, where he was ultimately promoted to Associate Aeronautical Engineer in charge of the Atmospheric Wind Tunnel and Special Flight Test Sections, Reid was associated with Fred Weick and collaborated with him in originating the famous N.A.C.A. cowling. In addition, he accomplished the first correlation of the effects of turbulence and support interference on sphere resistance and carried out the first American experiments on wing-tip shields, rotating cylinders, oscillating airfoils, suction boundary-layer control, and ground effect in full-scale flight.

In 1927, after 5 years with N.A.C.A., Reid joined the faculty of Stanford University to give graduate instruction and conduct research in aerodynamics.

At Stanford; he wrote *Applied Wing Theory* (McGraw-Hill, 1932), the first American textbook on that subject. He originated new methods of performance prediction and static stability analysis, did the aerodynamic design of a thick-wing, twin-boom airplane—the Vance monoplane—in 1930, experimentally verified the theory of nonuniform airfoil motion, and investigated the effects of the principal design variables—including dual rotation—upon propeller efficiency. He has also drawn attention to the reduction of thrust resulting from the increase of power input to overloaded propellers, demonstrated the effectiveness of annular-jet ejectors, and devised new instruments for propeller wake survey and the direct reduction of manometer records.

▶ **War Period**—During the war period, Professor Reid conducted wind-tunnel development tests of the Hughes D-2, the North American XB-28, and various Hamilton Standard propellers; investigated the lift of airfoils in steady and oscillatory pitching motions for the Air Force; and carried out a consulting assignment for the National Research Council.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One of his less academic, but more interesting, experiences was a ride from Muroc to Palmdale in the open nose cockpit of a modified Bell P-59 jet with a former student at the controls. Apparently the pilot relished the opportunity to an extent hardly befitting the dignity of a colonel, but, in the words of his victim, "It sure was fun!"

For relaxation, Professor Reid likes golf and bridge and, for a hobby, goes in for "very amateur photography." Married in 1926, he has one daughter.

Besides being a Fellow of the Institute, Professor Reid is an Associate Fellow of The Royal Aeronautical Society and a member of the Institute's Editorial Committee (Aerodynamics).

I.A.S. Sections

Baltimore Section

Don K. Covington, Jr., *Secretary*

The June 22 dinner meeting was held in the famed Levering Hall of The Johns Hopkins University. Seated at the speakers' table were Albert Kullas, incoming Section Treasurer; Welcome W. Bender, incoming Secretary; Ralph H. Draut, present Treasurer and incoming Vice-Chairman; Mrs. O. J. Schaefer, wife of the Section Chairman and Toastmaster; Don K. Covington, Jr., present Section Secretary; George S. Trimble, Jr., present Vice-Chairman; Guy L. Bryan, Jr., incoming Section Chairman and program committee member in charge of the dinner meeting; and Dr. Carl Lamanna, speaker of the evening. Total of 105 members and guests were present.

▶ **Germ Warfare**—Dr. Lamanna of Johns Hopkins Department of Bacteriology, School of Hygiene and Public Health, gave an informative talk on "Aspects of Biological Warfare."

"Any nation with a good brewery," said the speaker, "can make biological warfare agents." He added that the lay public "has been treated to a rather sensational account" of the possibilities of germ warfare. "An enemy could drop talcum powder bombs and if he could convince you it was a deadly germ, the effect would be as good as if it were," Dr. Lamanna declared.

The "catastrophic picture given to laymen" overlooked the development of antibiotic agents such as penicillin and the difficulty of spreading disease.

▶ **Germ Aerodynamics**—The matter of getting germs within at least 7 ft. of the ground, which Dr. Lamanna said was maximum for homo sapiens, also was a problem when one considered that the aerodynamic characteristics of germs often swept them to 10,000 ft. with an updraft of air.

At the conclusion of the talk, Mr. Schaefer introduced the newly elected members of the Advisory Board: Vernon Hauck; Dr. G. F. Wislicenus; and Dr. A. C. Charters. Next he introduced the members of the Board with 1 year of office remaining to serve, including Capt. Max Welborn, C. E. Roberts, Joel Jacobson, and F. D. Jewett.

Dayton Section

W. A. Barden, *Secretary*

On June 23, Major Gen. Frederick M. Hopkins, Jr., Chief, Industrial Planning Division, Air Materiel Command, gave a talk on "Some Aspects of U.S. Air Force Industrial Mobilization Planning" before 35 members of the Section. Colonel A. A. Arnhym, Chairman, presided.

Student Branches

Academy of Aeronautics

Two films were shown at the June 15 meeting, *Aerodynamics—Airflow*, and *Aerodynamics—Forces Acting on Airfoil.* The first explained turbulence and skin friction through the use of smoke, while the second showed the forces acting on an airfoil and the relationship between lift, drag, area velocity, thrust, and weight.

University of Detroit

A talk on "Graduate Study" was given at the June 28 meeting by Philip G. Blenkush, Instructor, in which he explained that most graduate study is highly theoretical, dealing principally with applied mathematics and advanced physics.

Indiana Technical College

At the June 22 meeting, requirements for an award to the most outstanding student in the Aeronautical Department were formulated.

Two films by Firestone were shown: *The Building of a Tire* and *Crucible of Speed.* Chairman Charles Bursey presided.

News of Members

Douglas Andreoli, M.I.A.S., has been transferred to the Project Engineering Office, Chance Vought Aircraft Division of United Aircraft Corporation, Dallas, Tex. Mr. Andreoli was also recently elected an Associate of The Royal Aeronautical Society.

Charles M. Armbrust, M.I.A.S., is now working at Goodyear Aircraft Corporation, Akron, as a Senior Designer. Former Layout Draftsman and Checker at The Glenn L. Martin Company, he now lives at 94 Davenport Ave., Akron, Ohio.

Important Notice

Papers for Presentation at Eighteenth Annual Meeting

Outlines or abstracts of papers to be considered by the Meetings Committee for presentation at the Eighteenth Annual Meeting in January, 1950, must be submitted no later than September 30.

Send to: The Secretary, Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

Lloyd E. Berggren, T.M.I.A.S., has been promoted from Assistant Project Engineer to Project Engineer, Wright Aeronautical Corporation, Wood-Ridge, N.J.

Sherman M. Fairchild, M.I.A.S., has been named Chairman of the Board of Fairchild Recording Equipment Corporation.

Thomas P. Goebel, T.M.I.A.S., has returned to work at North American Aviation as an Aerodynamicist after obtaining his professional degree in Aeronautical Engineering. New address is 6668 W. 86th St., Los Angeles 45, Calif.

W. J. Gornall, T.M.I.A.S., is now employed as Junior Stress Analyst, Gloster Aircraft Company Ltd.

Alfred H. Hobelman was elected President of the Washington Post, American Ordnance Association, at its 24th annual meeting in Washington. He is Assistant Vice-President of the Walter Kidde Company and an Associate Member of the Institute.

Carrol L. Howell, T.M.I.A.S., is Research, Development and Design Engineer at Wright Field. Address is now 166 Cambridge Ave., Dayton, Ohio.

J. R. Humphreys, T.M.I.A.S., formerly a Designer with Stone & Webster Engineering Corporation, Baton Rouge, La., is now associated with Beech Aircraft Corporation as an Engineering Draftsman and Service Test Pilot. New address is 5317 East Elm, Wichita, Kan.

PRESIDENT OF MARTIN

C. C. Pearson, M.I.A.S., has been elected new President, General Manager and a Director of The Glenn L. Martin Company by the directors of the 40-year-old pioneering aircraft firm. A veteran of more than 19 years of experience as an aircraft industry executive, Mr. Pearson was with Douglas Aircraft from 1930 until he joined Curtiss-Wright as a Vice-President in June, 1948. Mr. Martin expressed his gratification at having as his successor "a man of Mr. Pearson's qualifications."

Eugene B. Jackson, A.M.I.A.S., is now Chief, Technical Information Control Section, Research & Development Branch, Office of the Quartermaster General, Washington 5, D. C.

James Bernard Kelley, M.I.A.S., received his Doctor of Engineering Science (Aeronautical Engineering) degree from New York University last June.

Ronald J. Knapp, T.M.I.A.S., received his M.S.E. in Aeronautical Engineering from the University of Michigan and has accepted a position with National Advisory Committee for Aeronautics, Langley Field. He is stationed at Muroc Flight Test Base. New address is Box 1272, Lancaster, Calif.

Subramania Krishnan, M.I.A.S., is a Technical Observer with Pan American World Airways for the Government of India.

Howard M. Luttrell, T.M.I.A.S., has been transferred from the San Diego Division of Consolidated Vultee to the Ft. Worth Division. New address is Y.M.C.A., Room 439, Ft. Worth, Tex.

Marios Mavricos, T.M.I.A.S., is Aeronautical Engineer with Pan American World Airways. Address is 2360 35th St., Astoria 5, L.I., N.Y.

PIONEERING PIONEER

Aviation, which has its pioneer pilots, pioneer designers, and pioneer manufacturers, adds one more pioneer to its roster of honor—the pioneer passenger. S. L. Gabel, A.M.I.A.S., founder and administrative consultant of Superior Tube Company, Norristown, Pa., was one of the first ten passengers aboard the country's first transcontinental air passenger service. On June 23, 1929, Mr. Gabel was a passenger on the first of the "dress rehearsal" flights operated before commercially scheduled service was inaugurated July 8, 1929, by Trans World Airline, then Transcontinental Air Transport. As one who has been connected with aviation since 1915, Mr. Gabel was one of the pioneers of aviation who had the courage to be air-minded before airplanes held an established place in the economy.

Richard C. Messerschmitt, T.M.I.A.S., now is an Ensign, U.S. Navy, B.O.Q. Naval Air Station, Pensacola, Fla.

Leonard Meyerhoff was awarded the degree of Ph.D. in Applied Mechanics from the Polytechnic Institute of Brooklyn.

S. Radhakrishnan, T.M.I.A.S., is Aeronautical Engineer, Hindustan Aircraft Ltd., Bangalore, India.

Donald M. Simpson, T.M.I.A.S., is now employed by Boeing Airplane Company, Seattle, as Junior Engineer A. He was with The Glenn L. Martin Company as Senior Draftsman. New address is 2916 S. 200th St., Seattle 88, Wash.

Lee H. Smith, M.I.A.S., formerly Sales Manager for Beech Aircraft, has formed his own company, the Lee H. Smith Company, located at 6363 Wilshire Blvd., Los Angeles, Calif.

H. L. Vincent, M.I.A.S., former Navy Lieutenant Commander, now has joined the firm of Booz, Allen and Hamilton in Chicago, Ill.

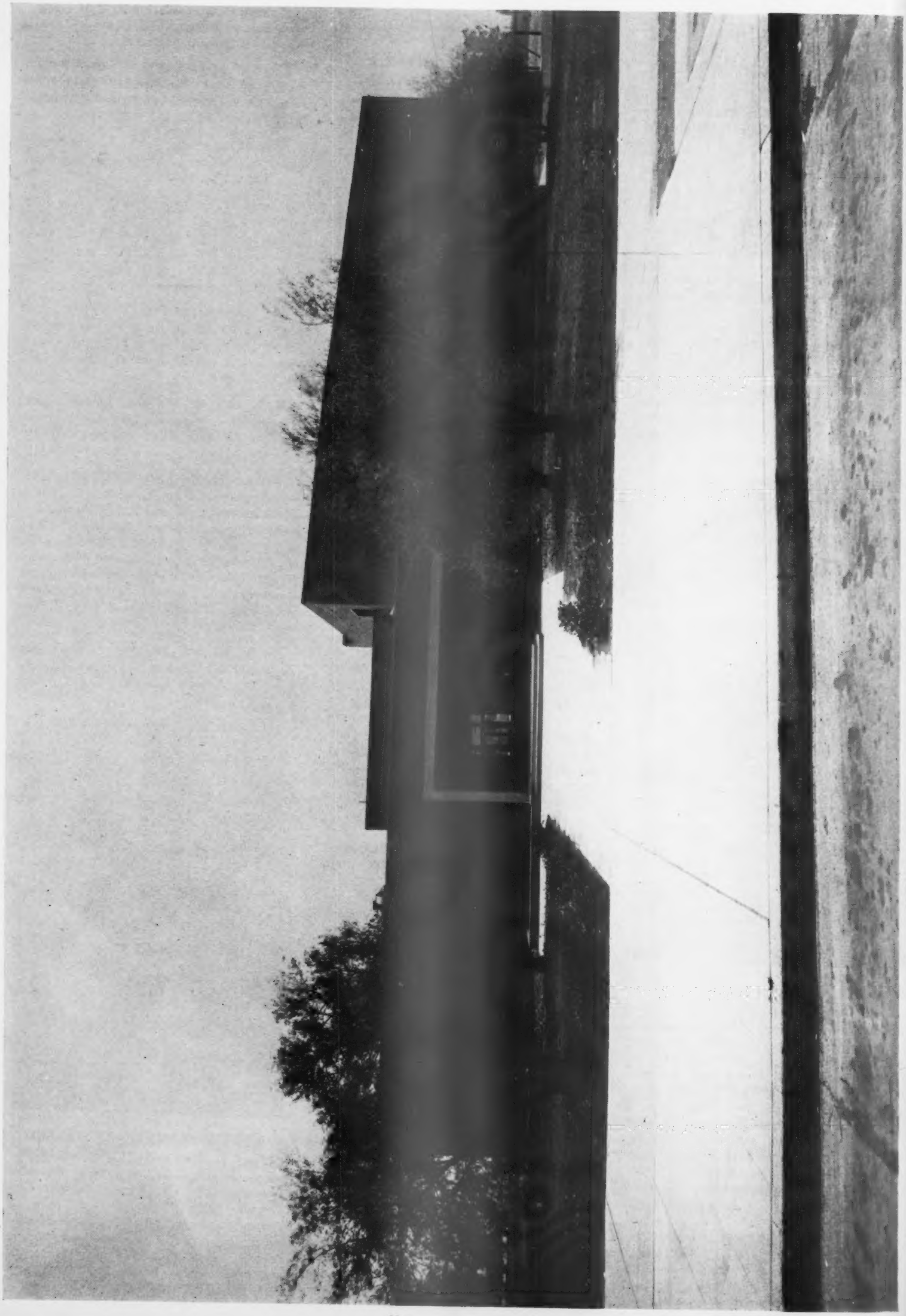
William M. Woollen, T.M.I.A.S., who was graduated from Cal-Aero Technical Institute, receiving the I.A.S. Award for the most outstanding record in scholastic achievement and engineering ability in his class, has obtained a permanent position as Junior Draftsman with the Mechanical Engineering Department of the University of California Radiation Laboratory, Berkeley, Calif.

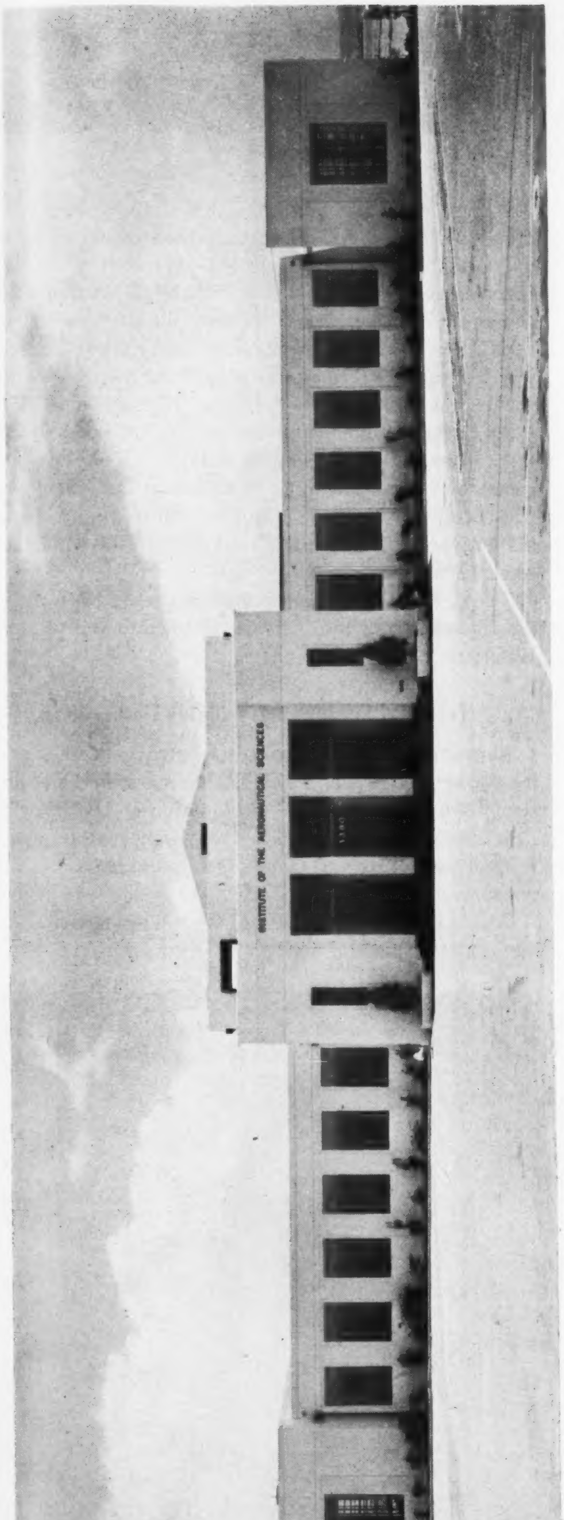
N. R. Whyatt, M.I.A.S., is Aviation Technical Officer, Royal Insurance Company Ltd., 24–28 Lombard St., London E.C.3, England

(*I.A.S. News continued on p. 94*)

TURBO-HYDROMATIC INSTALLED

Thomas B. Rhines, M.I.A.S., Chief Development Engineer, Hamilton Standard Propellers Division, United Aircraft Corporation (right), watches installation of division's latest propeller, the Turbo-Hydromatic, designed for use with gas turbine engines. Developed under Navy auspices, new prop recently passed 110-hour Army-Navy type test.





Editorial

Ready and Able—

Every engineer knows the feeling that comes from seeing a pet project emerge in three dimensions after long study and contemplation of its details simply as lines on paper. Such was the reaction of those of us who recently saw for the first time the magnificent new Institute facilities on the West Coast. There at last, ready and open for business, stood the two buildings that had occupied so much of our time, effort, and paper work for the past year. It was a good feeling.

Every I.A.S. member who attended the sessions of the Summer Meeting in the Los Angeles Building, or who participated in the official opening of the San Diego building later the same week, came away with a feeling of tremendous pride in our organization. We now have facilities in operation that will increase immeasurably the services that the Institute can perform for the aircraft industry.

We are particularly proud of our tenants in our Los Angeles Headquarters. The Western liaison office of the N.A.C.A. had already been installed in its new quarters at the time of the Summer Meeting. The Western office of the Aircraft Industries Association will have moved in by the time this issue comes off the press. These key aeronautical organizations, together with our Pacific Aeronautical Library and our own Western Headquarters offices, combine to form a center for technological aviation activities that has never before been equaled anywhere. Our building at 7660 Beverly Boulevard in Los Angeles has become the focal point for technical information for the aircraft industry west of the Mississippi.

To the donors who made these buildings possible, to the hard working committees who steered them through the difficult days of construction, and to Jim Straight, our Assistant Director in residence in California—our sincere thanks and congratulations for a job well done.

S. P. J.

I.A.S. Summer

More than 500 engineers and top-flight aeronautical people gathered in Los Angeles during the week of July 17 to participate in the Institute's Annual Summer Meeting program. In addition to hearing some well-prepared technical papers, they were privileged to be the first to initiate the new West Coast headquarters building.

It was nip and tuck that week between the carpenters, painters, electricians, and scheduled speakers as to who might occupy the platform the morning of the 21st. But the contractors pulled a rabbit out of somewhere, and only the earliest arrivals saw the last painter leave the stage at 8:00 a.m. that morning.

More can be (has been and probably will be) said about the beauty and utility of our new West Coast buildings. Space here permits only the use of a few randomly selected pictures and the passing remark that all Institute members can feel justly proud of these practical West Coast homes.

A Visit to Inyokern

The 4-day official program of the Summer Meeting got under way at 7:00 a.m. on Wednesday, July 20, with a field trip to Inyokern. Two hundred and twenty-six previously "cleared" I.A.S. members were flown by chartered airplanes from Los Angeles to this Naval Ordnance Test Station in the heart of the Mojave desert.

Here, Rear Adm. W. G. Switzer and members of his staff provided a well-planned demonstration and tour of N.O.T.S. facilities. This included a visit to the various research laboratories and Michaelson Museum and a viewing of some movies showing the work carried on at the Station. The group was also privileged to witness during the morning, the actual test-firing of several rocket missiles from the mile-long, high-speed track.

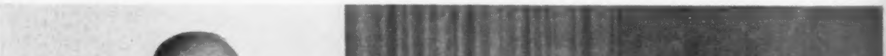
An informal luncheon was served at noon in the laboratory building's modern cafeteria. Those of the group who were scheduled to return to Los Angeles on the second of the late afternoon turn-around flights also enjoyed the facilities of the Officers Club while they were waiting.

The day's program terminated in Los Angeles, with a dinner meeting of the Institute Council at the Western Headquarters building.

Technical Sessions and Building Dedication

Thursday marked the formal opening of the technical program, with morning, afternoon, and evening sessions on Structures, Aerodynamics, and Guided Missiles scheduled. The Guided Missile Session was a "closed" meeting, restricted to individuals holding military clearances.

Edwin P. Hartman, Western Coordinator, N.A.C.A., has done a splendid job of fully covering the 2-day



Reuben H. Fleet, I.A.S. Past - President, acknowledges receipt of the Institute's Gold Key, presented to him at the San Diego luncheon in recognition of his work in conceiving and raising the funds for the two West Coast buildings. W. A. M. Burden, 1949 I.A.S. president, and Frank Fink *(right)*, Chairman of the San Diego Section, spearheaded the ceremonies.

Meeting

An Informal Report by

Welman A. Shrader

Technical Sessions. Nothing further need be said about them here. His story may be found on page 22.

At 11:30 a.m., a simple but impressive building dedication ceremony was held in the auditorium. S. Paul Johnston, I.A.S. Director, introduced President W. A. M. Burden, who delivered the dedication address. Mr. Burden recalled the circumstances leading up to the conception of Institute facilities for the West Coast by then-president Rueben H. Fleet and his subsequent efforts in raising the necessary funds. He lauded the many Los Angeles and San Diego members who had so unselfishly contributed of their time and effort to serve on various committees and see the big job through. In closing Mr. Burden paid tribute to the many West Coast companies whose foresight and financial support had made these facilities possible.

The dedication was followed by a buffet luncheon, served in the foyer.

Annual Summer Meeting Dinner

As in previous years, the Ambassador Hotel provided the setting for the Reception and Dinner on Friday evening, the 22nd. Three hundred and twenty-five guests were present in the Embassy Room for this occasion. President Burden acted as toastmaster, introducing the distinguished guests at the head table and making the presentations of the Bane and Chanute awards. Details of the awards and the 1949 recipients appear on page 5 in this issue.

One of the most enlightening speeches ever presented at an Institute gathering was delivered by Dr Lawrence R. Hafstad, guest speaker of the evening. Dealing with the highly confidential subject of atomic energy development and progress in this country, Dr. Hafstad revealed many interesting and heretofore unpublicized features of the A.E.C. program.

For the benefit of those unable to be present at the Dinner, the entire contents of his address have been published elsewhere in this issue. (See page 20.)

San Diego Visitation

A sort of "second," or postdedication, ceremony was held in San Diego on Saturday, July 23, mainly for the benefit of eastern members and I.A.S. staff who had been unable to attend the official building dedication dinner on April 29. This consisted of an informal luncheon, served in the building's auditorium, followed by ap-

(*Continued on page 49*)

Youngest "member" to attend technical sessions at Los Angeles, is Renee Lentz, daughter of Mr. and Mrs. George P. Lentz, of Muroc Air Force Base.

Willis M. Hawkins *(right)* and his F-24 Fairchild, in which he flew James L. Straight *(left)* and the author to San Diego for the dedication.

Los Angeles

Rear view of the I.A.S. building at Los Angeles.

Irene B. Gorsky, secretary to James L. Straight, I.A.S. Assistant Director, makes sure that all visitors buy luncheon tickets. Here, she has cornered John K. Northrop, W. A. M. Burden, Hall L. Hibbard, Reuben H. Fleet, Arthur E. Raymond, and Clark B. Millikan.

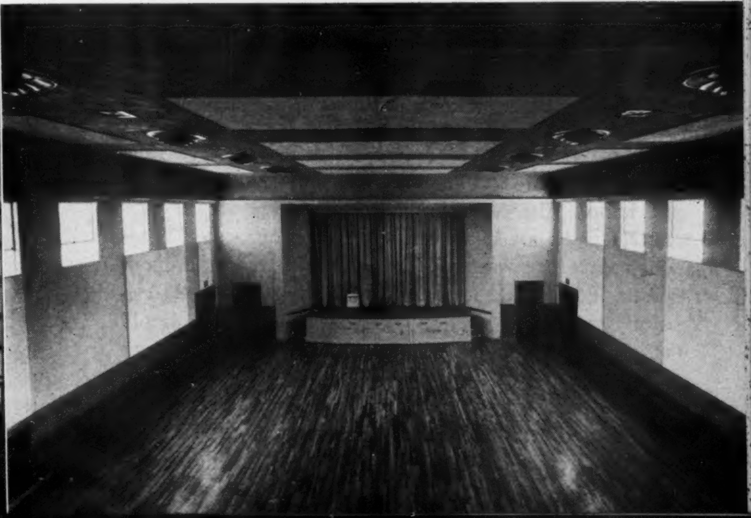
The dedication ceremonies at Los Angeles find I.A.S. President W. A. M. Burden well supported on the platform by various members of Contributors, Building, and Management committees, and I.A.S. New York staff personnel.

San Diego

Mrs. M. Goller, Librarian of the San Diego building, in her new, modern offices.

Formal dedication of the San Diego building took place on April 29, 1949, at which time the head table was comprised of *(left to right):* Edmund T. Price, Frank W. Fink, T. Claude Ryan, John K. Northrop, LaMotte T. Cohu, Ernest G. Stout, and Henry I. Mandolf.

A portion of the library reading room *(lower left)*, and the large auditorium that is suitable for dances, dinners, concerts, or lectures.



IT IS INDEED A PRIVILEGE to meet with this particular group tonight to present my impressions of the problems involved in the development of nuclear reactors—first in the general sense and, second, for the specific purpose of use in aircraft.

This group is especially qualified to appreciate the nature of the problems involved, both from a technical and from a policy point of view. Reactor projects have much in common with aircraft development projects. Both are expensive and risky. In both fields, one must obey the precept: "Be bold, be bold and ever more be bold, but be not too bold." Following that advice takes more than technical knowledge. It requires wisdom.

This report tonight is timely, too, for, since I have been with the Commission just long enough to learn the ropes, I should be able to give you the impressions of an outsider who has had the privilege of getting a good, hard inside look at the Commission's Reactor Program.

Of course, this assumes that I will be skillful enough to handle the security questions involved. Fortunately, I do not think this will be too difficult. What our competitor wants to know is: "What solutions or promising approaches have we found to specific technical problems?" What you gentlemen are probably most interested in is: "Is the objective we have set for ourselves worth attaining and are we going about it the right way?" These are questions peculiar to our own situation and our own frame of reference. The answers we get are certainly not those that are applicable to our competitor. In this area, therefore, we can afford to be frank without giving aid and comfort to the competitor.

Let us see if we can get squarely in mind just what we are trying to do in the overall atomic energy effort—not with respect to specific technical projects, but what are the things we have to do in a broad sense? These are, I would say:

(1) To maintain undisputed leadership in technical knowledge and facilities for the United States in all areas of the atomic energy field, either for war or peace.

(2) To establish a trained corps of personnel familiar with all areas of atomic research and, in particular, with nuclear radiation and its hazards. This corps is our standing army of the modern age and would have to be maintained to serve in time of war, even if not organized to contribute in time of peace.

(3) To organize task forces sufficiently competent to explore, and sufficiently alert to exploit, any technical advance that has promise for either peace or war.

(4) To have the wisdom to see that the effort expended in the above activities is somehow kept proportional to the probable returns.

As part of the above, some kind of reactor program is an essential part of the overall effort. Reactors are the machines for giving us the controlled release of nuclear energy and, as such, certainly have promise both for peace and for war. Though the spectacular aspects of nuclear energy has been oversold in the popular press, the stubborn fact remains that 1 lb. of ura-

Dr. Hafstad*

on

"*Atomic Power* and Its Implications for Aircraft Propulsion"

★ ★ ★ ★

Excerpts from the Annual Summer Meeting Dinner Address, Ambassador Hotel, Los Angeles, July 22

nium can be persuaded to release an amount of energy equivalent to 2,000,000 lbs. of coal. When all is said and done, atomic energy is certainly not the magic perpetual motion machine which has been publicized, but it has the inherent possibilities of providing an incredibly compact storage battery.

Let us look at this analogy a little closer. Our ordinary automobile battery delivers 6 volts and has a capacity of about 100 amp.-hr., or a total power storage therefore of roughly 1 hp.-hr. A weight of uranium equal to that of an automobile battery would be capable of delivering about 300,000,000 hp.-hr. Edison was a great inventor, but the famous Edison cell, produced after years of effort, brought forth an improvement of only 30 per cent over the conventional lead cell compared to a conceivable 300,000,000 per cent for the uranium energy source. I will return to the many difficulties later, but this analogy shows the challenge of the problem, the conceivable rewards, the "pie in the sky." It would seem that the possibility of nuclear reactors for power production must at least be explored. The '49ers had much less incentive.

What else can reactors be used for? In addition to energy, reactors produce neutrons. These, in turn, can be used to produce radioactive isotopes or to produce more, or other, fissionable material. So long as concentrated energy sources are desirable, fissionable material will be an "economic good." A stockpile of fissionable material would certainly be more useful than the gold at Fort Knox. In war, it could be used for bombs and might be used for propulsive power. In peace, it would be available for civilian power insofar as the supply, and the economics of the situation would permit. It would appear, therefore, that a stockpile of fissionable material is indeed desirable. Accepting this, then considerable effort would appear to be justified on a special type of reactor called a "breeder," which shows promise of helping to maintain, if not even augment, our supply of fissionable material.

To describe a breeder we must digress for just a moment to a technical detail. As most of you know, the element uranium, as it occurs in nature, is composed of two kinds—one variety slightly heavier than the other. The fissionable variety from which we can get energy has a mass of 235 units. The other unfissionable, has a mass of 238 units. The U-238 form is 139 times as prevalent as the U-235 form. The trick in a "breeder" type of reactor is this: With a proper choice and arrangement of materials, the neutrons produced in the initial natural U-235 fission processes can be captured—after they have released their energy—by the atoms of unfissionable U-238 and as a *by-product* used to convert the U-238 into a fissionable form of material. Thus it is conceivable not only that energy can be extracted from U-235 but that as a by-product we acquire a potential stockpile of fissionable material 139 times as great as we had when we started! With

(*Continued on page 42*)

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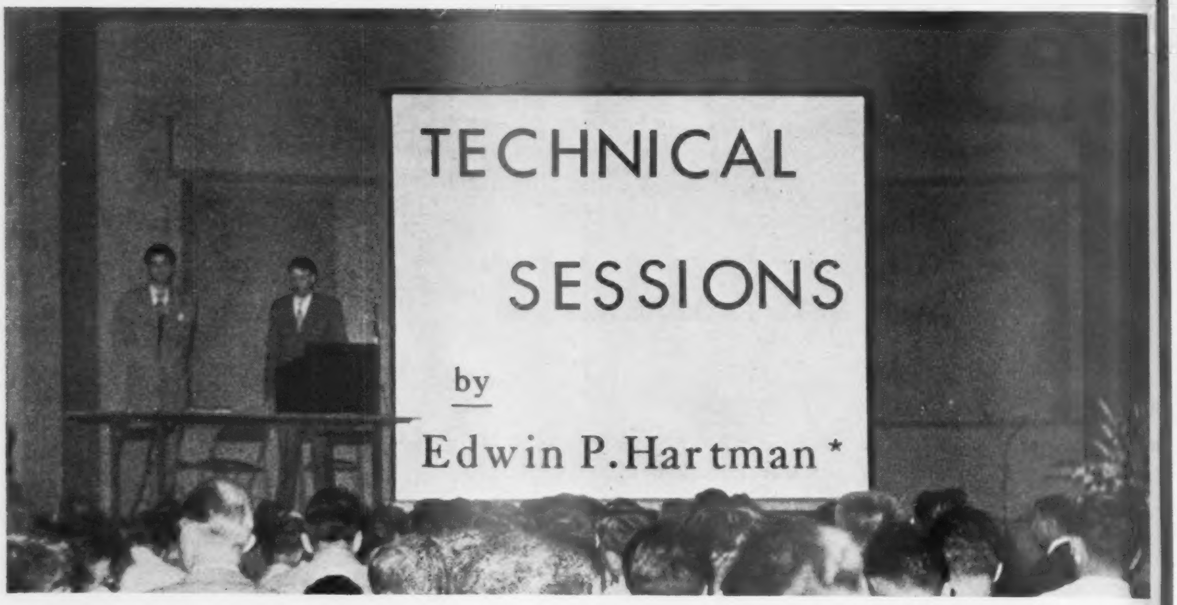
* Dr. Lawrence R. Hafstad, Director of Reactor Development, U.S. Atomic Energy Commission.



TECHNICAL SESSIONS

by

Edwin P. Hartman *

THE 1949 ANNUAL SUMMER MEETING of the Institute of the Aeronautical Sciences was a most auspicious occasion in that it marked the dedication and first official use of the Institute's handsome new Western Headquarters Building in Los Angeles. Dedication ceremonies, at which I.A.S. President W. A. M. Burden officiated, were held at 11:30 a.m. on July 21, the first day of the meeting.

Appropriate to an occasion of such moment, the Program Committee, chairmaned by Milton A. Miner, had arranged a fine array of technical papers, which were presented at morning and afternoon sessions on the first and second days and at an evening meeting on the first day. The evening meeting was a closed session dealing with material of a classified nature. It is worthy of note that, despite the new locale and new equipment (the last hammer blow of construction was still echoing in the halls as the meeting started), the Technical Sessions went off with remarkable smoothness and no major failure of equipment.

Structures

Dr. R. G. Folsom, of the University of California, was Chairman of the opening Technical Session, which was comprised of three papers in the field of structures. The first paper, presented by Lawrence B. Reynolds, of the Wright-Patterson Air Force Base, was entitled "A Summary of Flight Load Data Recorded in Tactical and Training Operations During the Period of World War II."

The procurement of maneuvering load data in aircraft has always been a matter of great importance to aircraft designers. Unfortunately, it is a tedious statistical procedure involving much time and trouble both in the procurement of the data and in their analysis. Mr. Reynolds, in his paper, described the results of the analysis of maneuvering load data obtained by the U.S. Air Force on various military aircraft during the course of World War II.

Most of the load data were obtained with V-G recorders. V-G records were obtained which covered approximately 105,000 hours of training and combat flight time on many makes of airplanes in both fighter and bomber categories. Among the makes of aircraft on which data were obtained are: F-51, F-47; British Spitfire and Typhoon; German ME-109 and FW-190; B-17, B-24, B-25, B-26; and the British bombers Halifax, Stirling, and Wellington. Records were obtained from flights at high altitude, at low altitude, and in both the European and Pacific theaters of combat.

The data for both fighters and bombers show a definite correlation with the lightness of controls. Thus, the airplanes with low stick forces (small stick force per g), as might be expected, encountered the highest maneuvering loads. The F-51, with a stick force per g of 0 to 8 lbs., was shown to be more susceptible to high maneuvering accelerations than the F-47, whose stick force per g was about 17. The British fighters, which, like the F-51, have light controls, also showed high maneuvering accelerations.

It is interesting to note that when the same type of airplane was flown in combat by both U.S.A.F. and British pilots, the airplanes flown by the British pilots received the higher accelerations. Accelerations were also higher, it was found, when anti-g suits were worn by the pilots, thus suggesting the existence of a physiological, or perhaps psychological, parameter.

The correlation of accelerations encountered with control lightness seemed also to hold for the bombers,

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* Western Coordinator, N.A.C.A.

with the more maneuverable B-25 showing substantially higher flight loads than the B-26. Also, it was noted, low-level bombing attacks resulted in generally higher loadings than high-level attacks. This result arose, no doubt, from the more violent evasive actions necessitated by low-level operation. Low-level attacks in the southwest Pacific theater, however, produced generally lower loads than similar attacks in the European theater. In the Pacific the attacks were often on small islands where the enemy countermeasures were geographically restricted and, perhaps, less well prepared.

On fighter aircraft, training operations resulted in greater flight loads than did combat operations, although on bomber aircraft no outstanding difference of this kind was observed.

Although the projection of World War II experience into the future is a somewhat dubious procedure, the author, in his paper, makes such an attempt and conservatively predicts greater flight loads for future jet combat aircraft.

The second paper of the Morning Session, "Analysis and Design of Stiffened Shear Webs," was delivered by Paul Denke, of Douglas Aircraft Company, Inc. Mr. Denke described a relatively simple graphical treatment of his earlier mathematical shear web analysis, which was published in the January, 1944, issue of the JOURNAL OF THE AERONAUTICAL SCIENCES. Mr. Denke's earlier analysis treated incomplete tension field web-stiffener combinations and represented a rationalization and expansion of the strain energy shear web analysis by Kromm and Marguerre, published in *N.A.C.A. Technical Note No. 870*. The mathematical analysis of the earlier paper was considered sufficiently rigorous and adequate, but the results were in a form difficult of application.

The four basic independent dimensionless factors involved in Mr. Denke's graphical analysis are the stress ratio $fsWL/(Et^2)$, the panel aspect ratio L/W, and the transverse and longitudinal stiffening ratios R_T and R_L. The effect of the quantity R_q of the earlier analysis, which relates to the bending flexibility of beam flanges, is accounted for through a modification of R_T and R_L, thus avoiding the introduction of a fifth and sixth independent variable. Important panel stresses, such as diagonal tension stress $\bar{\sigma}_1$, may thus be plotted as functions of the four independent variables. Actually, in all cases, the ratio of the desired stress to some power of the shear stress is plotted rather than the stress itself. This practice assures that all of the curves have asymptotes.

Among the factors plotted are f_L, f_T, $\bar{\sigma}_1$, web average longitudinal, transverse, and diagonal stresses, respectively; W_L, longitudinal stiffener local bending load; W_T, transverse stiffener local bending load; M_L, longitudinal stiffener local moment; and M_L, transverse stiffener local bending moment. The depth, length, and angle of the web buckles could not conveniently be plotted, but these are not ordinarily required.

Comparison of stresses determined from the earlier mathematical analysis and from the charts derived therefrom shows satisfactory agreement. Comparisons of stresses obtained by means of the charts with those obtained experimentally by the N.A.C.A. also show reasonably good agreement. The agreement is poorest for beams having stiffeners on one side of the shear web only. In such cases, the measured stresses were determined for the leg of the stiffener attached to the sheet, so that bending stresses were not eliminated. Corrections were made according only to the simple theory of flexure. The scatter of test points in these cases suggests the involvement of extraneous stresses. Thus, it is possible that the lack of agreement of the test data with that obtained from the charts may arise from inaccuracies of the test measurements.

As a supplement to his presentation of his graphical analysis method, Mr. Denke included in his paper a description of the behavior of both flat and curved shear panels, covering such items as the principal causes of web, stiffener, and rivet failure. The use of the graphical method for analyzing some of the situations covered in this description were also presented.

Mr. Denke concluded that the graphical method he had presented was a rational, easily applied, and satisfactory accurate procedure for determining stress distribution in stiffened shear webs. Although only the stress analysis of panels was demonstrated, Mr. Denke anticipates that additional investigation and refinement will establish the validity of the method as a means of predicting ultimate load. He also expects that the method will prove applicable not only to thin web beams but also to curved wing and fuselage panels.

The third paper of the Morning Session, presented by Edward Rossman, of the Lockheed Aircraft Corporation, was entitled "Gust Criteria for Airplane Design." Mr. Rossman made a strong case for revising and standardizing our methods for computing gust loads on aircraft structures. Present methods of determining gust loads and load factors on airplanes, he declared, are inadequate. Furthermore, he pointed out, the gust load requirements of various licensing and procurement agencies (C.A.A., Navy, Air Force) are not uniform, nor are they clear as to the distribution of gust loads on aircraft components.

It was stated that the need for rationalizing present method of determining gust loads is urgent if proper consideration is to be given to the effect of the high degree of flexibility found in modern aircraft. The accurate determination of gust loads is also considered essential to the investigation of aircraft structural fatigue and life expectancy.

Gust loads, as presently computed, are based on the following parameters: (1) slope of lift curve; (2) wing loading; (3) alleviation factor; (4) gust velocity; and (5) airplane velocity.

While agreeing that these factors are the ones that should properly be considered in their gust-load formulas, the procurement and licensing agencies do not agree on the definition and values of some of the terms.

Aerodynamics Session Panel of Speakers: *(left to right) Dr. Francis H. Clauser, Chairman, Aeronautics Department, The Johns Hopkins University; Arthur L. Jones, Ames Aeronautical Laboratory, N.A.C.A.; Harold Mirels, Lewis Flight Propulsion Laboratory, N.A.C.A.; Harold Luskin, Aerodynamics Research Engineer, Douglas Aircraft Company, Inc. Michael Pindzola, Research Engineer, Research Department, United Aircraft Corporation, also delivered a paper but was not present for the above picture.*

For example, of the four major specifications (CARO4, ICAO, Air Force, BuAer) for airplane strength, one recommends that the slope of the lift curve be taken as the slope of the wing lift curve, whereas two others require that it be taken as the slope of the airplane lift curve, and the fourth specification does not state how the lift curve slope is to be defined. A difference of 20 to 25 per cent may exist between the slopes of the wing, and airplane, lift coefficients. Furthermore, unsettled questions arise as to whether the static or dynamic slope of the lift curve should be used and as to whether or not that portion of the wing inside the fuselage should be considered in the calculations.

The C.A.A. (CARO4) requires that a gust velocity of 30 ft. per sec. be used, while the Air Force and Navy specify a gust velocity of 50 ft. per sec. In all three cases, however, the alleviating factor is juggled so that the resulting gust load factors come out about the same. The superficiality of the treatment is thus evident.

While the present empirical methods of computing gust loads may have been acceptable in the past, it does not, in Mr. Rossman's opinion, provide a satisfactory basis for the design of modern aircraft. He feels that it is high time a rational method is developed for determining the response of an airplane to a gust—a method wherewith the loads in both the wing and tail could be determined together with the load factors.

How is such a method to be developed? It has already been done, Mr. Rossman said, in a thesis that he prepared recently while attending the University of Washington. The title to Mr. Rossman's thesis is "Equations of Motion and Response of an Airplane in a Gust," dated 1949.

The development of the equations of motion, Mr. Rossman explained, is based on two degrees of freedom—that is, vertical and pitching motion. The gust intensity in the spanwise direction is assumed to be uniform. Two sets of equations of motion are written. First, with only the wing penetrating the gust, the response of the airplane is computed; then, the case of only the tail penetrating a gust is considered and the response is computed. The net response is then determined by superposition.

Before concluding his talk, Mr. Rossman discussed a number of important factors in gust-load calculations. These included lift lag, gust gradient, length of gradient, effect of control motion, compressibility, and sweepback.

Aerodynamics

Dr. Francis H. Clauser, of The Johns Hopkins University, was Chairman of the Afternoon Session on July 21. Four papers in the field of supersonic aerodynamics were presented. The first one, entitled "Supersonic Tests of Conventional Control Surfaces on a Double Wedge Airfoil," was delivered by Michael Pindzola, of the United Aircraft Corporation.

Mr. Pindzola described tests of a 7 per cent thick, symmetrical, double wedge, flapped airfoil made in the United Aircraft Corporation's supersonic wind tunnel at Mach Numbers of 1.38, 1.48, and 1.58. The U.A.C. wind tunnel, as used in these tests, had a two-dimensional throat of dimensions 3.7 by 15.4 in. The tunnel is designed for continuous operation, making use of a vacuum-type system in which part of the mass flow can be recirculated. This feature allows for control of stagnation air temperature which, in these tests, to avoid condensation difficulties, was kept at 175°F. Mach Number changes were obtained by nozzle replacements. The nozzles were made of laminated mahogany.

The model was mounted from the tunnel floor on a small shielded strut. The strut enclosed pressure leads, as well as rods, for changing the angle of attack of the airfoil during the tests.

The data obtained in these tests were in the form of complete pressure distributions and schlieren photographs. Lift, drag, moment, and centers of pressures were computed from the pressure distributions. The schlieren photographs contributed a better understanding of the physical significance of the pressure data.

The experimental results obtained from these tests were compared with existing first- and second-order linear theories, as well as the shock-expansion theory by Ivey, Stickle, and Schuettler given in *N.A.C.A. Technical Note No. 1143*. In all cases, the results agree favorably with second-order linear and shock-expansion theories up to points where flow irregularities, such as separation or detached bow wave, occur. The effect of bow wave detachment on the comparison of theory and experiment is shown in Fig. 1, taken from Mr. Pindzola's paper.

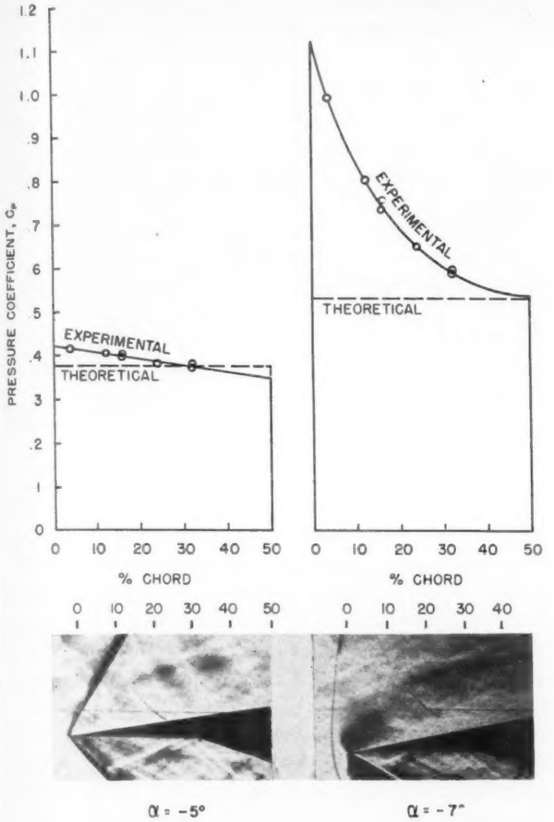

FIG. 1. Detached bow shock effect at $M = 1.48$ on airfoil of 7 per cent thickness.

Flow separation occurred chiefly in the after portion of the airfoil, at the flap hinge line, and sometimes moved forward from the hinge line. Flow separation, of course, decreased the lift coefficient, increased the slope of the moment curve, and decreased both the flap hinge moments and effectiveness.

The second paper of the Afternoon Session was presented by Arthur L. Jones of the N.A.C.A. Ames Aeronautical Laboratory. Its title was "The Theoretical Lateral-Stability Derivatives for Wings at Supersonic Speeds." In this paper Mr. Jones attempts to summarize and analyze the results of existing, analytically determined, lateral stability derivatives for a variety of supersonic wing plan forms. The subject is difficult to handle in a rigorous and lucid fashion, and its presentation by Mr. Jones drew numerous comments from supersonic experts in the audience.

Before going into the details of the summary, Mr. Jones reviewed the history and concepts of dynamic stability analysis, pointing out that this tool had become increasingly popular with aircraft designers and seemed now to be reaching its zenith of utility in connection with the design of supersonic aircraft. He observed that, although the increases in airplane speed during the past 15 years had not materially affected the classical form of the equations of motion, it had produced a significant effect on the values of the derivatives that appear as the coefficients of these equations. The transition from subsonic to supersonic speeds, in fact, changes the sign, as well as the magnitude, of the derivatives in some cases.

Mr. Jones reviewed briefly the methods of analysis used in supersonic wing stability theory. He pointed out that the linearized theory of compressible flow as applied to thin airfoils was perhaps the most useful in the calculations of supersonic stability derivatives. It was noted that, although the theory is based on the assumptions of small angles of attack and small perturbation velocities, similarly restricted theories for subsonic flow have yielded surprisingly accurate results. Furthermore, comparisons that have been made between theoretical values and available experimental supersonic data on lift curve slope have been encouraging. While the theory is expected to be satisfactory for nonviscous flow, it was noted that the principal effects of viscosity are on C_{n_r} and can be estimated independently.

One of the first steps in the general solution of lifting surface analysis is the establishment of the boundary conditions. Sideslip and roll produce no great difficulties in this respect, and a sideslipped flat plate at an angle of attack can be represented by a uniform distribution of downwash perturbation velocity over the plan form. Also, the rolling wing is readily represented by a linear spanwise variation of downwash perturbation velocity. The boundary conditions for the yawing wing, however, are not so easily prescribed; in fact, the yawing wing is not truly adaptable to steady-state solution and should be considered as an unsteady flow problem.

As a result of this boundary condition situation and other factors, most of the reported stability calculations have been made only for C_{l_p} the damping in-roll derivative. Beyond this one derivative, much of the material on lateral stability derivatives has come from research groups at the N.A.C.A. Langley and Ames laboratories. Much of the information summarized in Mr. Jones' paper came, thus, from these two groups.

The summarized results covered four plan forms described as: (a) rectangular, (b) trapezoidal with tips raked outward, (c) triangular with apex forward, and (d) sweptback and tapered to points at wing tips, having subsonic leading edges and supersonic trailing edges. The main objective of the summary was to show the effects of aspect ratio and Mach Number on the derivatives. The data were presented in the form of charts of stability derivatives plotted against Mach Number and aspect ratio.

The summary revealed that, in general, the magnitudes of the supersonic derivatives were fairly comparable to those encountered at subsonic speeds. The effect of increasing aspect ratio appeared to be to increase the magnitude of the stability derivatives due to rolling and to decrease the magnitudes of derivatives due to sideslip.

It was shown that the magnitudes of the derivatives generally tend to increase as sonic speed is approached from the subsonic side and to decrease as the Mach Number is increased on the supersonic side.

Nonlinearities that occur for rolling moment and yawing moment in sideslip are indicated as being primarily due to edge suction force.

The third paper of the Afternoon Session was entitled "The Calculation of Supersonic Downwash Using Line Vortex Theory" by Harold Mirels and Rudolph C. Haefeli of the N.A.C.A. Lewis Flight Propulsion Laboratory. The paper was delivered by Mr. Mirels.

His method for calculating supersonic downwash, Mr. Mirels explained, was a straightforward procedure based on the lifting-line theory. There exist several other methods based on linearized theory, but these methods are based on integral expressions for the downwash which are complex and tedious of evaluation. A logical approach to the development of a simplified supersonic downwash theory, Mr. Mirels asserted, was to derive the supersonic analogs of the line vortex procedures that have proved valuable in incompressible flow theory. Certain differences that exist between the properties of vortices in incompressible flows and supersonic flows must, however, be investigated before the extension of the subsonic techniques is possible.

Following this preliminary discussion Mr. Mirels proceeded with a detailed attack on the two main objectives of his paper: (1) presentation in explicit form of the downwash field induced by a line vortex segment of constant slope and the utilization of this expression to explain some of the properties of line vortices in a supersonic free stream; (2) presentation of lifting line methods for computing supersonic downwash and the comparison of several calculations, based on these methods, with the exact linearized solutions.

The author's discussions relative to these objectives covered the classical vortex field relations involving circulation, vorticity, and the surface distribution of vorticity. Also discussed were linearized supersonic wing theory relations as related to the vortex field generated by a lifting surface in a supersonic stream. The upwash field due to a line vortex segment of constant slope was considered, as was also the infinite line vortex inclined both supersonically and subsonically. A line vortex is supersonically or subsonically inclined, Mr. Mirels explained, depending on whether the component of the free-stream velocity normal to the line is, respectively, either supersonic or subsonic.

Mr. Mirels introduced the concept of the bent-line vortex, stating that it could be considered as a superposition of two vortex segments. The resulting upwash in this case is

$$w = (K/2\pi)\,[G_1\,(m^-) - G_1\,(m^+)]$$

where K is circulation and m^- and m^+ designate the slopes of the line vortex before and after the bend at x_1, y_1. The upwash in this case exists only in the downstream Mach cone from x_1, y_1 and is infinite on the cone surface except in the $z = 0$ plane. If $m^- = \infty$ and $m^+ = 0$, a horseshoe vortex results, and the upwash is zero except within the Mach cone from the band.

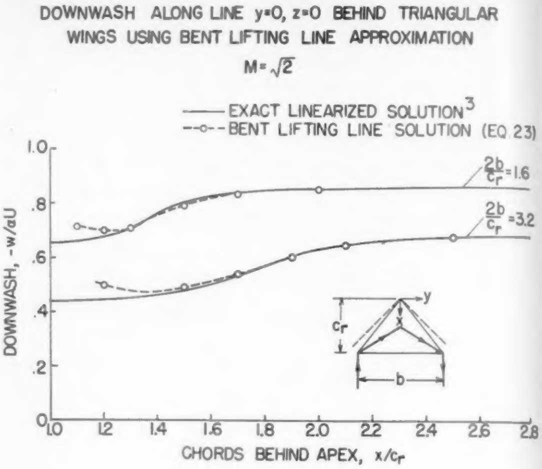

FIG. 2.

The bent-line modification of the lifting-line theory was then developed, and two examples of downwash calculations using both the bent and the unbent lifting-line theories were worked out. One example was for a triangular wing with subsonic leading edges, and the other was for a rectangular wing. In the case of the rectangular wing, the unbent lifting-line solution checked closely with the exact linearized solution. As shown in Fig. 2 covering the case of the triangular wing, the bent lifting-line solution was in good agreement with the exact linearized solution.

Mr. Mirels admitted that the load distributions may be modified by viscous effects and by larger perturbation velocities than are permitted by linear theory. He expects that an experimental program will ultimately be required to determine the necessary modifications to theory that will make it conform with practice.

The last and very interesting paper of the Afternoon Session was delivered by Harold Luskin, of the Douglas Aircraft Company, Inc. Mr. Luskin's paper "Predictions of Supersonic Airplane Performance" lay in a field in which he has had considerable experience, both good and bad. He began by describing the frightful errors of earlier prognosticators and then, smothering trepidation with bravado, proceeded with predictions of his own concerning that most questionable of all subjects—aircraft performance.

Mr. Luskin had excavated material from musty tomes to show the untrustworthiness of growth curves as a basis for predictions of future developments. For example, the recorded value of horsedrawn vehicle production during the period from 1850 to 1900 presaged a bright future for the buggy business. Then came the automobile, and gigs and surreys were a dime a dozen with no takers. Growth curves have a habit of collapsing in mid-flight or, in other cases, having proceeded lethargically for some time, will take a sudden spurt as if stung by a bee. The bee is usually a new invention or the application of some new principle. All of this discussion, of course, merely served as a warning to crystal-ball curve extrapolators and provided an appropriate background for Mr. Luskin's predictions.

The difficulty of predicting the speed of future jet-propelled supersonic airplanes is illustrated by Fig. 3, taken from Mr. Luskin's paper. It is observed that in the case of the airplane powered with a reciprocating engine the top speed is definitely established by power required and power available curves that intersect at a substantial angle. In the case of the future airplane powered with a gas turbine or gas turbine with reheat, the thrust required and thrust curves run almost parallel. In cases where excess thrust is small, minor changes in the value of drag or thrust will produce vast changes in maximum speed. In cases where excess thrust is large, the maximum speed of the airplane may very well be determined by factors, such as aerodynamic heating, other than thrust and drag.

Approximate calculations made by Mr. Luskin on a number of aspects of airplane performance are shown in Fig. 4, taken from his paper. This figure shows the speed limit imposed by aerodynamic heating assuming a stagnation temperature (300°F.) dictated by the strength properties of aluminum alloys. Provisions for refrigerating the crew, instruments, accessories, tires, etc., for continuous operation at such stagnation temperatures will, Mr. Luskin asserted, introduce a weight penalty of about 10 per cent of the empty weight of the airplane. Furthermore, the weight penalty will increase rapidly with speed.

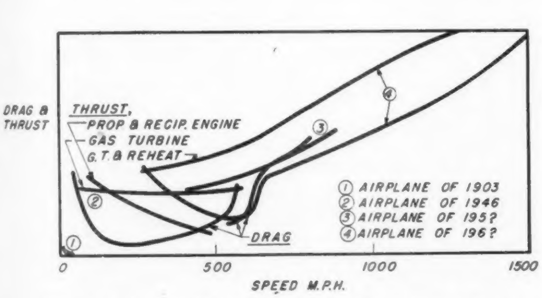

FIG. 3. Drag and thrust curves for several aircraft.

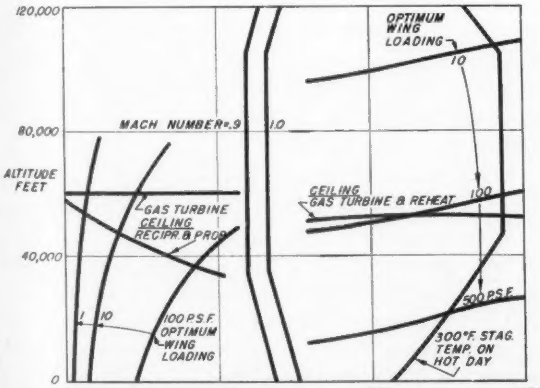

FIG. 4. Airplane performance limits.

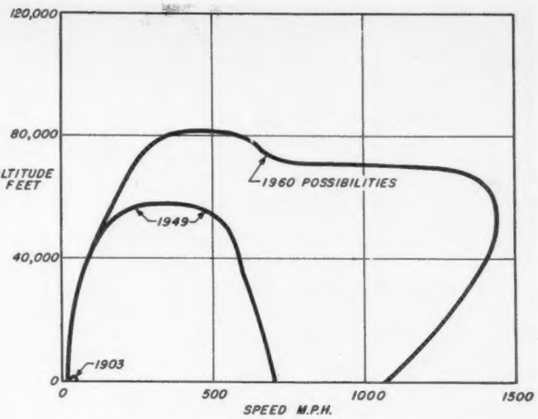

FIG. 5. Airplane performance history.

On the basis of all preceding considerations and the best guess that present knowledge will permit, Mr. Luskin made a prediction of the altitude and speed performance that may be attained by aircraft by 1960. These predictions are indicated in Fig. 5, taken from his paper.

Design

The Chairman of the Morning Session on July 22 was S. J. de France of the N.A.C.A. Ames Aeronautical Laboratory. Three papers were presented. The first one was by J. B. Wassall, of the Lockheed Aircraft Corporation, entitled "Design and Development of the Lockheed P2V Airplane." Mr. Wassall had an important share in the development of the P2V (Neptune) airplane, and no one is in a better position than he to discuss its design details.

The paper was an account of the development of an airplane that has proved to be highly successful. Successful airplanes are not so common that their story is not worth telling. The P2V, while not completed in time to get into much, if any, of wartime military activity, has, since war's end, fully demonstrated its potentialities as a naval patrol and attack bomber. It has a top speed of more than 300 m.p.h., a nonstop cruising range of more than 5,000 miles, and the ability to stay aloft for at least 36 hours without refueling. It is fully equipped with radar for search work and is prepared to attack an enemy with machine guns (six, 20 mm.), rockets, torpedos, or bombs. Some versions have also been adapted for photographic reconnaissance.

The world record for nonstop, nonrefueling flight has been held by the P2V since September, 1946, when it flew from Perth, Australia, to Columbus, Ohio—a great circle distance of 11,236 miles. The P2V also has the distinction of being the largest airplane ever to have been flown from an aircraft carrier. Assisted by JATO rockets, the P2V, at a gross weight of 75,000 lbs. (75 lbs.

Design Session Speakers: *(left to right) Chairman, Smith J. de France, Director, Ames Aeronautical Laboratory, N.A.C.A.; J. B. Wassall, Chief Production Development Engineer, Lockheed Aircraft Corporation; Roland J. White, Boeing Airplane Company; George Papen, Group Engineer, Production Design, Lockheed Aircraft Corporation; Paul Sandorff, Group Engineer, Research, Lockheed Aircraft Corporation.*

per sq. ft.), has demonstrated successful take-offs from the aircraft carrier U.S.S. "Coral Sea."

The general configuration of the P2V is well known to everyone. It is a clean high-wing, two-engined monoplane of essentially conventional appearance. It has a gross weight of about 64,000 lbs. supported on wings of 1,000-sq.ft. area and 100-ft. span. The engines to be used in the latest P2V airplanes are the Wright R-3350-30W compound engines.

The P2V benefited by sound design judgment and numerous laboratory and flight-test programs, including tests in at least five different wind tunnels. Needless to say, careful attention was given to structural soundness, structural simplicity, serviceability, maintenance, producibility, and general reliability. Special attention was given, of course, to those features essential to the primary tactical functions of the airplane. Long range required clean high aspect ratio wings and efficient engine operation; high speed required clean overall lines and smooth surfaces; the need for taking off and landing from small fields required high lift coefficients, obtained (2.6) by proper airfoil selection, Lockheed-Fowler flaps, and drooped ailerons; good flying qualities were obtained by careful consideration of stability and control surface design and the use of such devices as internal sealed aerodynamic balances on control surfaces, power boost rudder control, downspring on elevator, varicam (variable camber) three-component articulated horizontal surface.

In all history the exercise of the best design judgment has never turned out an airplane that, from the first, was entirely satisfactory in all respects. So it was with the P2V. A number of design faults became evident in early flight tests. Fortunately, none of these faults were serious, and they have been satisfactorily corrected.

The second paper of the Morning Session, entitled "Investigation of Lateral Dynamic Stability in the XB-47 Airplane," was delivered by Roland J. White, of the Boeing Airplane Company. Everyone, of course, is acquainted with Boeing's spectacular swept-wing bomber and, thus, there was much interest in hearing Mr. White describe an ingenious way in which an instability problem had been solved in that airplane.

The instability showed up in early flight tests of the XB-47 in the form of a Dutch Roll. It was attributed to insufficient damping in yaw, particularly at low speeds and at substantial altitudes. The low damping in yaw introduced the Dutch Roll motion, the roll component of which was considered by the pilots to be particularly objectionable. There is something basic about this form of instability, Mr. White thinks, as it relates to modern airplanes having a high density factor $(u = W/g/\rho Sb)$. It is a problem, he believes, that will be encountered with increasing frequency in the design of new airplanes, and its solution will take some positive and original action on the part of airplane designers.

Various means for improving the damping in yaw of the XB-47 were considered. Such conventional means as increasing the vertical tail area or decreasing the wing dihedral were found by analysis to be impracticable or otherwise not feasible. Wing dihedral could not be decreased much because of ground clearance requirements with flaps extended and the need for more dihedral at high speeds. Likewise, it was found that to correct the difficulty the vertical tail area would have had to be greatly increased, thus introducing additional drag area, weight, and directional roughness.

The idea of correcting the yawing perturbations by automatically deflecting the rudder was conceived and put into effect. This objective was accomplished by putting a rate gyro in the rudder control system in such a way that any tendency to yaw is quickly damped by gyro-controlled rudder motion. The XB-47 has a full power boost rudder control with artificial feel introduced by a spring. The gyro control element was installed so that, under ordinary conditions, the feel of its action on the rudder did not return to the pilot. The pilot, however, does sense the effects of the gyro-stabilizer in making steady turns. In such cases the gyro system bucks the turning action of the airplane, producing an effect of high directional stability and necessitating the use of fairly high pedal forces. Boeing engineers, who feel that the gyro-stabilizer system is generally satisfactory, are working on a means for correcting this minor fault.

The action of the Boeing gyro-stabilizer is well illustrated in Fig. 6, taken from Mr. White's paper.

As indicated by a comment made by Dr. A. L. Klein at the conclusion of Mr. White's address, there are those who deplore the resort to "gadgets" to solve aircraft stability problems. These individuals feel that the use of such devices represents a short cut and dangerous solution to problems that should be solved by simpler and more basic aerodynamic design methods. The compounding of safety devices, Dr. Klein declared,

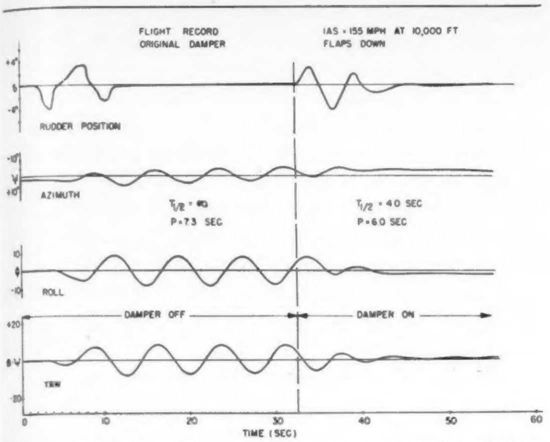

Fig. 6. Operation of yaw damper at approach condition.

represents a serious hazard in itself. The use of the Boeing device would, of course, be more questionable than it is if it were used to solve a problem of catastrophic instability. This is not the case, however; the XB-47 instability was merely troublesome, not particularly dangerous, and thus failure of the gyro device is not likely to have serious consequences.

The third and last paper of the Morning Session on July 22 was "Integrally Stiffened Structures" by Paul Sandorff and G. W. Papen, of the Lockheed Aircraft Corporation. The paper was delivered by Mr. Papen. It represented a thorough study of the advantages and the possibilities for the manufacturing and economical use of plates with integral, built-in stiffeners. The paper was more than an analytical study. It also indicated the considerable extent to which Lockheed has engaged both in laboratory experimentation on the manufacturing processes of integrally stiffened plate, as well as in the experimental application of this type of structure to actual airplanes.

The advantages of integrally stiffened structure lie principally in the reduction in number of parts and attachments and the reduction in handling expenses and assembly tooling. Other advantages include reduced weight, improved surface smoothness, rigidity, and simplified sealing. Certainly all of these items are important in airplane construction, and a number of them are becoming of increasing importance in the design of modern high-speed aircraft. Radical changes in the structural design of airplanes is contemplated so the design inertia in the introduction of integrally stiffened plates might be easily overcome at this time. The big question in the use of such material would, thus, seem to be in the solution of the technical and cost problems of its manufacture. Mr. Papen discussed both of these items in some detail.

Among the different means considered by Lockheed for the manufacture of integrally stiffened plate are machining from plate, slab milling, rolling, extruding, and press forging.

Machining from plate, performed with an end mill, is a wasteful process because most of the material is converted into chips. As an experimental project, Lockheed used this process to manufacture a leading-edge structure, similar to that used on the Constellation outer wing, from $^{1}/_{4}$-in. plate. The skin of this structure was given a thickness of 0.04 in., and a doubler pad 0.072 in. thick was left on all edges to simplify attachment. Forming was accomplished after milling by repeated bumping on a power brake.

Slab milling, performed on heavy spar milling equipment, was found to be a rapid method of making integrally stiffened plate, though the process is generally less flexible than the end mill method. In examining this method of construction, Lockheed has used an Onsrud spar miller to produce span-length wing panels out of $^{7}/_{8}$-in. plate. These panels have been incorporated in the upper surface of an experimental wing for the Constellation airplane.

Lockheed has observed closely, and with interest, the work of the Aluminum Company of America and the Reynolds Metals Company in rolling ribbed sheet. The company has also followed closely the work of The Dow Chemical Company in the extrusion of integrally stiffened sheet specimens. Both of these processes, of course, are in an early stage of development.

The production of thin-skinned surface panels with deep-section integral stiffeners by press forging has become more feasible with recent advancements in technique and press capacity. The Germans did some pioneering work along this line during the war. They used a press of 30,000-ton capacity. The largest one in this country is of 1,800-ton capacity.

The press forging technique may be useful even if forging to finished contour proves to be impossible. A rough forging would greatly reduce the amount of machining required as compared with the machining-from-slab process.

Air Navigation

The Afternoon Session on July 22 was devoted to the subject of Air Navigation. Its chairman was Joseph Marriott, of the C.A.A. Sixth Regional Office. Four papers were presented, three of which dealt with various design equipment and operational aspects of the new C.A.A. Omni-Directional Radio Range, officially known as VOR (Visual Omni-Range). The first of the papers, delivered by F. L. Moseley, of the Collins Radio Company, was entitled "The Operation of the VHF Omni-Range in the Transitional System."

Mr. Moseley's paper provided a general description of the design and operation of the Visual Omni-Range and also a detailed description of some of the air-borne equipment associated with VOR that is built by the Collins Radio Company.

In the past the system of four-course low-frequency aural range has been the principal radio navigation aid for aircraft enroute. This system is now being supplemented with a nation-wide network of approximately 400 VHF omnirange (VOR) stations and will even-

Air Navigation Panel of Speakers: *Chairman, Joseph Marriott, Administrator, Sixth Region; C.A.A.; Francis Gross, Radio Development Division, C.A.A.; J. Wesley Leas, Air Navigation Development Board, C.A.A.; E. A. Post, Superintendent, Navigational Aids, United Air Lines, Inc.; Francis Mosely, Collins Radio Company.*

tually be replaced by them. The new VOR system offers several advantages over the older system. It provides clear, static-free reception of voice communication and visual navigation information under all weather conditions. Voice communication of excellent quality and navigation information is simultaneously transmitted over the same radio channel.

The pilot of an airplane equipped for VOR reception is no longer restricted to four courses but may elect to fly along any chosen bearing line, through the range to which he is tuned, with the aid of a sensitive visual deviation indicator. Furthermore, the pilot will be able to connect this indicator to the automatic pilot and enjoy automatic flight along a course line that he has selected. He may also obtain bearings from two omnistations and, thus, fix the position of the aircraft.

The omnirange signals are sent out from a special transmitter equipped with a group of five antennas (one central and four circumferential). The central antenna transmits the station's frequency (assigned frequencies lie between 112.0 and 117.9 mc.) modulated with a 10 kc. subcarrier, which in turn is modulated by a 30-cycle signal. The aircraft receives a steady 30-cycle signal of fixed phase from this antenna. The four circumferential antennas are alternately fed with an unmodulated carrier signal so as to produce a rotating figure-of-eight pattern that sweeps the receiving antenna of the aircraft at the rate of 30 r.p.s. Suitable circuits within the aircraft receiving equipment compare the steady and rotating signals and determine the bearing of the aircraft relative to the station. The accuracy of bearing determination is ±2° at favorable elevation angles and ±3° at unfavorable elevation angles.

The air-borne receiver is equipped with a frequency selector, an omnibearing selector, a deviation indicator, and a radio magnetic indicator. The frequency selector enables the pilot to select any one of 280 crystal controlled frequencies spaced 0.1 mc. apart, between 108 and 135.9 mc. The omnirange feature of the receiver may be used in different ways. For example, the knob of the omnibearing selector can be rotated until the deviation needle is centered and the "To-From" needle indicates "To." When this is done, the number appearing in the window of the bearing selector is the magnetic bearing from the aircraft to the station. It is not affected by the heading of the aircraft. If the pilot wishes to fly to the station, he orients the aircraft so that its heading is approximately equal to the indicated bearing and then flies the aircraft so as to keep the deviation needle centered.

The VOR equipment has built-in safety features. Failure of either the ground or air-borne equipment will be indicated by warning devices in the airplane.

The omnirange system and its various components have been in operational use for nearly 2 years on a constantly expanding basis. The principal air lines of the United States are engaged in installation and training programs aiming toward early operational use of the VOR system on scheduled runs.

The second paper of the Afternoon Session was entitled "Some Operational Aspects of Distance Measuring Equipment in the Transitional Air Navigation System." It was delivered by J. Wesley Leas, of the Air Navigation Development Board.

Mr. Leas described an item of equipment, yet under development, which eventually will be a valuable adjunct to the omnirange (VOR) navigation system. The VOR system as has previously been described is essentially a polar coordinate (R/θ) system in which the values of bearing (θ) of aircraft to central station are readily obtained. The distance-measuring equipment (DME) discussed by Mr. Leas provides the R of the polar coordinate system and, thus, permits a definite fix of the aircraft relative to the central transmitter station.

The DME is similar to the responder beacons of airborne radar. An air-borne item of DME, called the "interrogator," sends out a pulse train that is received by ground equipment called a "transponder." The transponder, upon receiving the interrogator signal, triggers a transmitter associated with it and returns a signal of its own. The reply received by the aircraft gives a measure of time, which is converted into distance and presented visually to the pilot. Once the station distance is determined, it is tracked automatically as it increases or decreases, and a continuous indication of the distance is provided on an indicator dial of the air-borne DME. It is to be noted that DME measures slant distance from aircraft to station and, thus, the altitude of the airplane when directly over the station.

As previously mentioned, DME is still under development and a number of items such as range, accuracy, traffic control capacity, number of channels, etc., are still unsettled—thus, open for discussion.

The range, it is felt, should be at least half the distance (about 45 miles) between range stations and, for certain special applications, a great deal more.

To be consistent with the accuracy (2° or 3°) of the omnibearing system, the DME need have an accuracy of no more than from 3 to 5 per cent. Its use for spacing airplanes in traffic-control patterns will likewise not require an accuracy of better than 5 per cent. On the other hand, if used in connection with ILS, high (perhaps impracticably) accuracy is required.

It was concluded by Mr. Leas, after pro and con discussion, that DME should have the same number of channels (100) as are now assigned to the VHF navigation system (VOR and ILS). The air lines and certain military aircraft plan to use a common control head such that the setting of a VOR frequency channel will also set the DME channel corresponding to it and the choice of an ILS localizer frequency will also tune in the DME channel as well as the glide path transmitter channel.

DME has been under development in this country since 1945. The C.A.A. and Air Force are planning on letting production contracts during the fiscal year 1950, with the Navy following shortly. The commercial air lines are in the process of preparing their specification for the air-borne equipment. DME is expected by Mr. Leas to be in operation in approximately 3 or 4 years.

The third paper of the Afternoon Session was "The Development of a Course Line Computer for the Air Navigation System" by C. B. Watts, Jr., and F. J. Gross. The presentation was made by Mr. Gross. Mr. Gross gave a concise description of the new VHF Visual Omni-Range system and its operation and then described in some detail a "course computer" accessory now being developed for use in connection with that system.

The course computer development represents another valuable effort to exploit the many possibilities offered by the new omnirange navigation system. It requires special air-borne equipment, the final design of which has not been completely fixed.

The course computer equipment has a number of important uses. It can, for example, be used to fly the airplane to a waypoint on a course that does not pass over the station. It will also permit an airplane to be flown along a course that is parallel, but offset some desired distance, from a radial line through the omnistation. The latter feature is expected to be useful for traffic control and the avoidance of congestion over an airport.

As described in the earlier papers, the omnirange establishes a polar (R/θ) diagram enabling pilots to fly radially along a desired angular (θ) course to or from the station and the distance-measuring equipment establishes the value R. Now, the course computer appears and adds another degree of navigating flexibility by permitting the pilot to fly along desired nonradial courses. Clearly this represents a large advancement in air navigation and air traffic control.

In using the equipment, say to fly to a way station, the pilot has to set three constants into the instruments. Two are the bearing and distance of the omnitransmitting station to the waypoint, and the additional item is the desired course to the way station. From then on the pilot merely flies so as to keep the deviation needles centered. If distance-measuring equipment is available, it will continuously show the distance of the airplane from the waypoint. The flight to the waypoint may also, if desired, be along some offset course.

Extension flight tests, using one omnibearing station at Indianapolis, have shown overall system errors no greater than 2 miles within 50 miles of the station. The course computer unit itself, when produced in quantity, is expected to contribute an error of less than 1 mile for a distance of 50 miles from the station.

The fourth and concluding paper of the Afternoon Session was entitled "Airline Operation Experiences with the Instrument Landing System" and was delivered by Edgar A. Post, of United Air Lines, Inc.

Mr. Post began his presentation with a historical review of instrument landing system development leading up to the present "Instrument Landing System," a term that he considers a misnomer, as the ILS in use today is in reality an "Instrument Low Approach System." Indeed, Mr. Post feels that our idealistic efforts to develop a "zero-zero" blind landing system have delayed our attainment of a useful system that will permit reliable approaches to be made to 200-ft. ceilings and $^1/_2$-mile visibilities.

Actually, United Air Lines pilots have made completely blind landings in a DC-3 with ILS. This performance was possible because the pilots had just completed an intensive course of ILS training. Ordinarily, performance of this kind is not expected and approaches to 200- or 300-ft. minimums are all that should be required.

In the use of ILS the pilot flies down a narrow two-component radio beam to the landing strip using his deviation indicator as a guide. The vertical-plane component of the radio beam is called the glide slope beam and the horizontal-plane component the localizer beam. Vertical radio markers, set at known distances along the course to the airstrip, give the pilot a signal when he passes over them.

At Washington, LaGuardia, Chicago, and Los Angeles airports, precision beam radar, previously known as GCA, is used to monitor all ILS approaches. If the radar shows that an approaching aircraft is appreciably off the ILS approach path, the pilot is so advised so that he may make the necessary corrections. While precision beam radar and ILS have their respective advantages and disadvantages, used together they provide the pilot with the safest surest instrument approach system available today.

As an indication of the usefulness of ILS, Mr. Post related that, during 28 days of bad weather in the months of December, 1946, and January and February, 1947, 87 per cent of all air-line instrument flights

(*Continued on page 96*)

Multistaged Centrifugal Compressors for Operation at High Pressure Ratios

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Wright Aeronautical Corporation

INTRODUCTION

As improved high-temperature materials are developed and improvements made in various methods of cooling hot rotating and stationary turbine parts, the temperatures of turbojet and turboprop combustion chambers will be increased in order to obtain higher specific thrust. As these temperatures are increased, higher pressure ratios will be required in order to obtain minimum specific fuel consumption. The purpose of this paper is to discuss various ways of combining more than one centrifugal compressor in order to obtain these higher pressure ratios.

The centrifugal compressor has many inherent advantages with two of the most important being its ease of manufacture and the vast background of knowledge that has been accumulated as a result of the extensive development work done in the past. In addition, the centrifugal compressor is most durable and capable of operation under a great number of adverse conditions such as ice and sand. It seems essential, therefore, to study the possibility of multistaging the centrifugal compressor for obtaining the desired high pressure ratios.

In selecting the pressure ratios to be considered, we have selected an upper limit of approximately 50 to 1 and made most of the comparisons at 20 to 1. For any airplane speed and combustion chamber temperature using reasonable component efficiencies, there is a pressure ratio that gives minimum specific fuel consumption (pounds per hour per pound of thrust) and another but lower pressure ratio giving maximum specific thrust (pounds thrust per pound of air per second). For turbojets at supersonic speeds and combustion chamber temperatures somewhat above those in use today, a compressor pressure ratio in the neighborhood of 20 to 1 gives minimum specific fuel consumption. As airplane speeds and thereby the ram are increased, the minimum specific fuel consumption tends to occur at a lower pressure ratio. The use of pressure ratios over 50 to 1 would only be indicated by super-high-combustion-chamber temperatures or subsonic airplane speeds. Such pressure ratios would involve extremes in structure and stresses such as machined-forged combustion chambers with extremely thick and heavy walls.

This study is of necessity based upon certain fundamental assumptions as to the adiabatic efficiencies obtainable in the individual stages, as well as the interstage passage pressure losses. It is felt that sufficient experience has been obtained at the Wright Aeronautical Corporation to indicate that the assumed values are obtainable. Fig. 1 shows the basic individual stage compressor performance used in calculating the adiabatic efficiency for any of the multistage machines. Peak adiabatic efficiency and pressure ratio are given as functions of impeller equivalent tip speed. This performance is for a 13-in. diameter impeller and is taken from Fig. 8 of reference 1. Although the performance shown is for a particular compressor, it closely represents an envelope of peak efficiency obtainable for any compressor in this pressure ratio range. Admittedly, most present-day turbine engines do not use an impeller of this small size, but testing at Wright Aeronautical Corporation has indicated that this small-scale performance can be readily equaled with increased size compressors. You may note that the curve does not extend beyond 3 to 1 pressure ratio for this typical single-stage centrifugal compressor. The advantages of a turbojet or turboprop engine with only one stage of centrifugal compression may well indicate that pressure ratios higher than 3 to 1 should be considered for such a case even at a slight loss in efficiency. However, at this time we are discussing more advanced pressure ratios in which it can be shown that more than one stage is necessary to obtain reasonable efficiency.

The calculated efficiency given for multistage machines is based on the assumption of an interstage loss between the first and second stage of 1.5 in. of mercury for operation at sea level and 0 m.p.h. airplane speed. Losses in the succeeding interstage passages are assumed to vary directly with increasing density in the succeeding passages This assumption of loss increasing with density is based on the requirement that succeeding interstage sections would be sized to give the same velocity as in the first to second interstage, and therefore the loss would be a function of density alone. We have also assumed a design point calculation where the matching of stages is optimum such that operation in the individual stages is at peak efficiency for each stage. This optimum matching is, of course, difficult to obtain when consideration must be given to surging problems at starting and acceleration up to rated or design condition.

Presented at the Fourth National Flight Propulsion Meeting, I.A.S., Cleveland, March 18, 1949.

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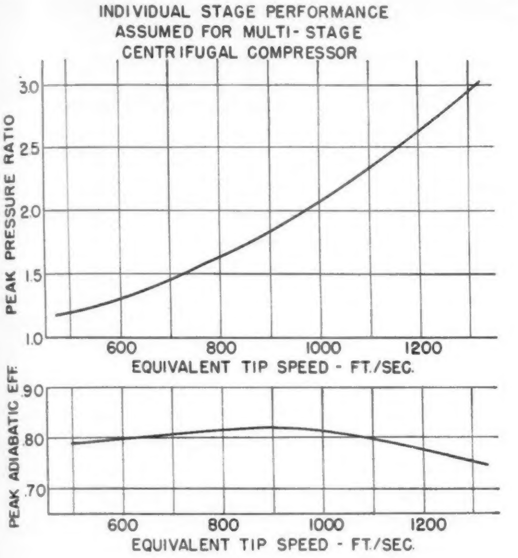

FIG. 1.

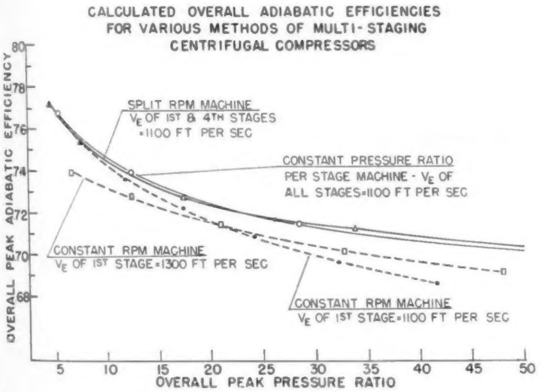

FIG. 2.

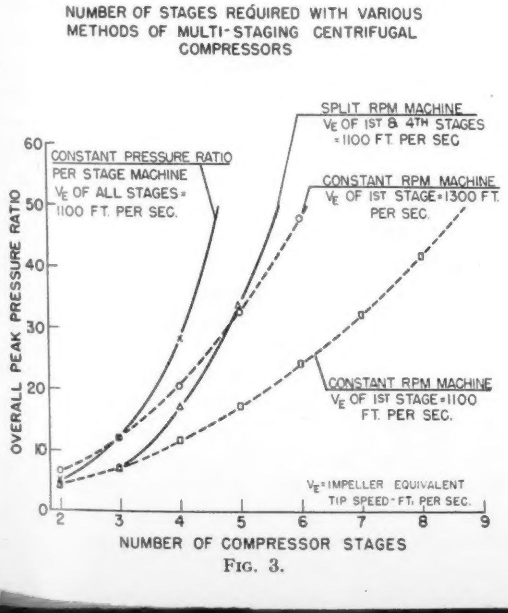

FIG. 3.

CONSTANT R.P.M. MACHINE

The first method of multistaging considered is that most commonly used and consists basically of a series of impellers all rotating at the same r.p.m. on the same shaft without intercooling. To maintain a constant outside diameter machine, it is also generally desirable to have the same diameter impellers in all stages. With this type machine it is inherent that the impeller *equivalent* tip speed in successive stages become lower and lower as a result of the increased entering temperature resulting from work of compression in the previous stage. This reduced impeller equivalent tip speed in turn results in less pressure ratio from each succeeding stage. Fig. 2 shows the calculated overall peak adiabatic efficiency versus the over all pressure ratio for several methods of multistaging the centrifugal compressors. Two of these curves as noted are based on the type of machine using constant r.p.m. and constant diameter of the impellers. One of these curves is based on the use of an equivalent tip speed of 1,100 ft. per sec. in the first stage, while the other is based on an equivalent tip speed of 1,300 ft. per sec. It is seen that the 1,100 ft. per sec. tip-speed machine gives a higher overall peak efficiency than the 1,300 ft. per sec. machine up to approximately 21 to 1 pressure ratio where the curves cross and the 1,300 ft. per sec. machine becomes better. The 1,300 ft. per sec. machine eventually becomes more efficient overall, because, having less stages than the other machine, it has less interstage drop, which becomes a large factor when the pressure ratio put out by the later compressor stages is so small. Referring now to Fig. 3, which shows the peak pressure ratio versus the number of stages for the various methods of multistaging centrifugal compressors, it is seen that four stages are required to obtain approximately 21 to 1 pressure ratio with the 1,300 ft. per sec. equivalent tip-speed machine. The 1,100 ft. per sec. tip-speed machine requires five stages to give only a 17 to 1 pressure ratio. The fifth stage of the 1,100 ft. per sec. machine is giving a pressure ratio of only 17.3/11.8 or 1.45. It should also be noted in Fig. 2 that above approximately 10 to 1 overall pressure ratio there is less than one point overall efficiency difference between the two different equivalent tip-speed machines. Thus, the choice here should be made on consideration of complexity and producibility rather than overall efficiency.

CONSTANT PRESSURE RATIO MACHINE

The second type of multistaging considered is one in which the pressure ratio per stage is maintained constant. This would require maintaining the same equivalent tip speed in all stages, which could be done either by providing variable r.p.m. for all stages or by gradually increasing impeller diameter in successive stages. When the impeller diameter is increased, it in turn becomes necessary to increase diffuser outside diameter and, therefore, the outside diameter of the machine in order to maintain the desired relationships for optimum performance. Unless the turbine size is a great deal more than the compressor size, it is not reasonable to exceed the outside diameter of the first compressor. Even if the installation does allow some increase, the consideration of weight due to the diameter increase is objectionable. Thus we would be faced with providing for the constant pressure ratio and constant equivalent tip speed of each stage by providing a different r.p.m. for each stage. This usually means gearing, which is both complicated and heavy, and also introduces a problem at off-design point conditions where the speed relation between stages is dictated by the gearing and may be different than that for optimum performance at design conditions.

Referring again to Figs. 2 and 3, we note that the constant pressure ratio machine indicates an efficiency that at all pressure ratios is somewhat better than the constant r.p.m. machine having the same first-stage equivalent tip speed. The efficiency advantage for using this system is approximately one point in overall efficiency in the pressure ratio range from 16 to 26 to 1. This constant pressure ratio machine requires only four stages to give approximately a 28.5 to 1 pressure ratio, as compared to six stages for the constant r.p.m. machine at a lower pressure ratio of 24 to 1. The efficiency advantage is considered minor when weighed against the disadvantages of complex and heavy gearing. However, four stages of the constant pressure ratio machine type with attendant gearing may still be no heavier than six stages of the constant r.p.m. type of machine.

SPLIT R.P.M. MACHINE

A third method of staging is the so-called split r.p.m. machine type. This method provides that the first stage or stages turn at one r.p.m. while some of the latter stages turn at a higher r.p.m. Such a practice has also been considered for axial compressors because of the large decrease in efficiency at the extremely high diameter ratios. When axial compressors are designed for pressure ratios greater than 8 or 10 to 1, the diameter ratio of the last stage exceeds 0.90. Therefore, pressure ratios above 10 to 1 call for a second high-pressure axial compressor of smaller diameter and greater r.p.m., thus allowing a smaller diameter ratio. This split r.p.m. type of centrifugal machine may again require gearing between two different shaft speeds. It is also possible to consider the split type machine combined with free wheeling, which will eliminate the use of the heavy and complicated gearing. In this case, the first stage or stages of the turbine drive the higher speed compressor or compressors on a shaft that is not connected with the low-speed shaft but rotates concentrically with it. The latter stages of the turbine drive through the central shaft to the front compressor or compressors. This eliminates the gearing problem but still presents the problem of control and operation at starting and cruising speed.

There are many ways of dividing the split two-speed machine, especially when a range of pressure ratios through 20 to 1 up to 50 to 1 is considered. However, as far as efficiency is concerned, there is not too great a difference between the various methods of speed division between the various stages. The overall efficiency shown on Fig. 2 for the split machine type is one that, at approximately 20 to 1 pressure ratio, has three stages rotating at the low speed while the remaining stages are rotating at a higher speed such that the fourth stage has the same equivalent tip speed as the first stage. The curve of Fig. 2 indicates that this type two-speed machine has an overall efficiency value that is higher than the constant r.p.m. machine and approximately equal to the constant pressure ratio per stage machine. Examination of Fig. 3 shows that the disadvantage of the split r.p.m. machine compared to the constant pressure ratio machine is that it requires four stages to give an approximate 17 to 1 pressure ratio whereas the constant pressure ratio machine with the same number of stages gives a 28.5 to 1 pressure ratio.

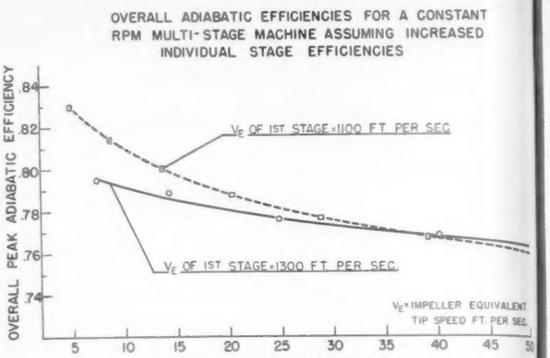

FIG. 4.

The question may arise as to what effect an improvement in the individual stage performance would have upon the comparisons made between the various methods of multistaging. A series of calculations was therefore made for the constant r.p.m. machine in which it was assumed that the individual stage efficiencies shown on Fig. 1 were improved five points at all tip speeds, with a corresponding increase in pressure ratio such that the slip factor remained constant. Fig. 4 shows that the choice of a higher basic single-stage efficiency line does not alter the conclusion that, above 10 to 1 pressure ratio, the overall efficiency is not appreciably affected by the type of machine or equivalent tip speed of first stage.

Now, to recapitulate, we refer again to Fig. 2, which shows that the overall efficiency is not so different for the three types of machines considered when all types had the same equivalent tip speed for the first centrifugal stage. At less than 10 to 1 pressure ratio, the overall efficiency is appreciably higher when a lower equivalent tip speed is used in the first stage. However, even this choice of higher equivalent tip speeds does not appreciably affect the overall performance for pressure ratios above 10 to 1. Thus, if we are considering pressure ratios over 10 to 1, we should select the type of machine on other considerations rather than overall efficiency.

CONSIDERATIONS OTHER THAN EFFICIENCY

The type of machine which provides a higher speed, lower diameter compressor in the last stage has an advantage over the other types in that a better turn can be made into the combustion chamber because the combustion chamber will probably be as large in diameter as the initial compressor. It is also possible that some accessories could be located around this section without exceeding the outside diameter of the machine. Of course, one of the big advantages is the weightsaving due to the smaller diameter.

In selecting the type of machine, the number of stages required is an important consideration. More stages mean a more complicated design because of the increased interstage passages returning the air from the large diameter outlet of one stage to the small diameter inlet of the next succeeding stage. This raises the problem of bearing support and air seals between stages along the shaft and shaft critical speed as well. All these factors tend to increase the design complexity and thereby the weight of the machine. All of these extra parts mean that the design is not so readily producible as another one of lesser number of stages.

One of the other considerations in choice of type is the factor of impeller and diffuser blade height to passage length. The efficiency calculations were made on the basis of a common efficiency curve for any compressor at any equivalent tip speed, but this factor holds true exactly only for a dynamically similar design. On the constant r.p.m. type machine, as the density is increased from stage to stage, the impeller blade height is reduced, while the impeller diameter and path length through it are not reduced. Thus, dynamic similarity is not maintained, and the stage efficiency will probably be reduced because of the higher percentage of passive to active surface. The same consideration holds true for the diffuser.

There is an additional problem of the practical actual tip speed of which the centrifugal impeller is capable. For instance, at approximately 17 to 20 to 1 pressure ratio, the fourth stage of the split machine considered has an actual impeller tip speed of 1,560 ft. per sec. with an entering air temperature of 586°F. This problem in itself probably calls for a steel impeller rather than an aluminum one. Even the steel impeller is not good enough for 1,700 ft. per sec. actual tip speed and the 770°F. temperature required of the last stage of a 28.5 to 1 constant pressure ratio machine.

INTERCOOLING

All the above comparisons were made without intercooling between the centrifugal compressor stages. Intercooling will, of course, help to improve the overall efficiency and reduce the number of stages required for a given pressure ratio. For example, calculations for the split r.p.m. machine previously discussed showed that, with intercooling, the adiabatic efficiency was increased from 0.728 to 0.965 and the pressure ratio increased from 17.4 to 22.1 for the same number of stages. The calculations were based on assumptions of an intercooler between each stage having an effectiveness of 0.65 and a separate source of cooling air for each stage. We should note that, with a compressor and intercooler combination as figured herein, it is possible to obtain over 100 per cent overall efficiency because the efficiency is based on actual overall enthalpy or temperature rise. The enthalpy removed by the intercooler is not charged to the compressor efficiency but is paid for by the cooling air enthalpy increase.

Although it does improve compressor overall efficiency, intercooling adds a few other problems that make it unattractive for multistage centrifugal compressors in the range of 20 to 1 pressure ratio. The air-to-air intercooler is usually too large to go in the small space between centrifugal compressor stages. Therefore, it must be placed outside of the engine with large and intricate ducting to and from the intercooler. There is considerable airplane drag added because of the cooling airflow necessary to cool the intercooler. By the same token, although a liquid-cooled intercooler might be made small enough to go in the required space, the size of the radiator required to be placed outside in the airplane structure is so great that considerable airplane drag is added because of the necessity for providing cooling airflow to this radiator. Also considerable complication and weight is added in order to pump the liquid coolant. Intercooling helps a great deal in lowering the temperature entering the latter stages and thus allows higher tip-speed operation from the mechanical point of view.

COMPRESSOR MATCHING

The performance figures shown in Fig. 2 are only applicable if it is assumed that there is optimum matching of all the stages of the compressor—that is, that each stage is operating at its peak efficiency. It is difficult to obtain this optimum matching condition at design point without sacrificing starting or acceleration conditions. It may be that one or more of the stages may have to operate in a surge condition all the way from starting to 80 per cent of rated speed. The attainment of optimum matching conditions at design point without serious surging difficulties at lower speeds requires a great deal of development and testing work on both single and multistage compressors.

Fig. 5 shows a single-stage compressor rig used at Wright Aeronautical Corporation for determining the impeller performance in large diameter vaneless diffusers. After impeller performance and capacity have been determined, the impeller is then tested in a vaned diffuser in a single-stage rig, of the type shown on Fig. 6, to ensure proper matching of impeller and diffuser capacities. Once the individual stages have been developed to give maximum range of operation

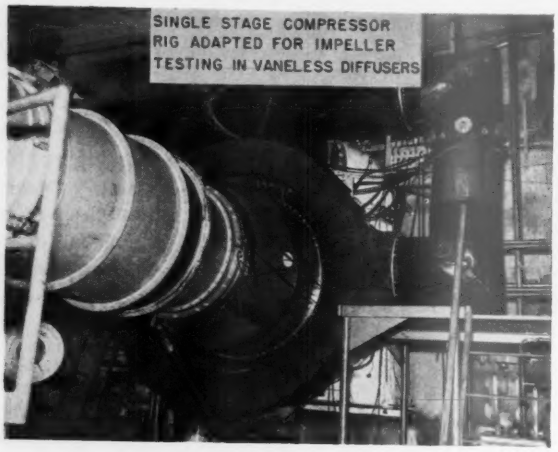

FIG. 5.

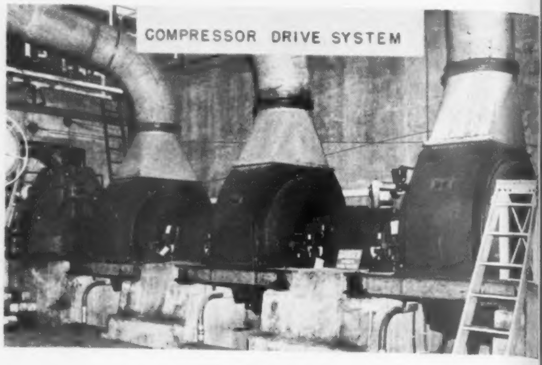

FIG. 8.

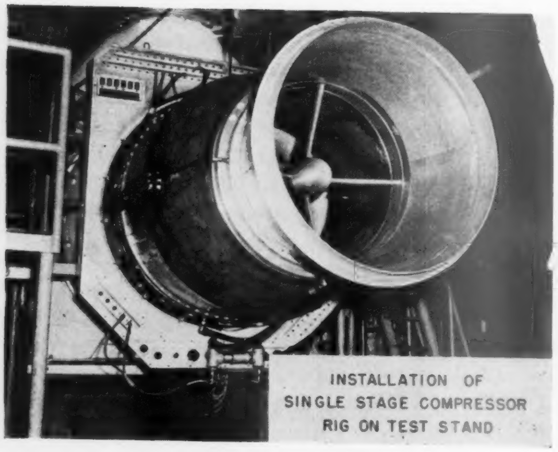

FIG. 6.

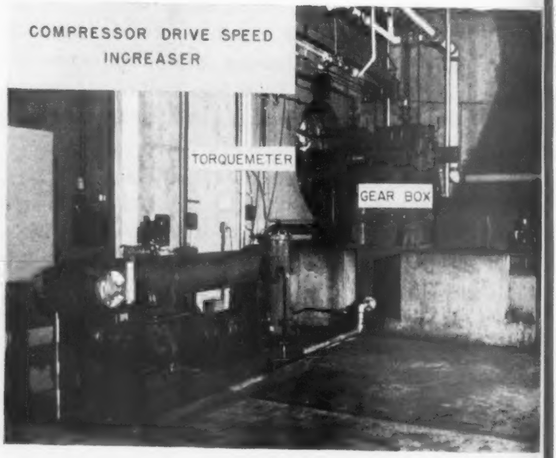

FIG. 9.

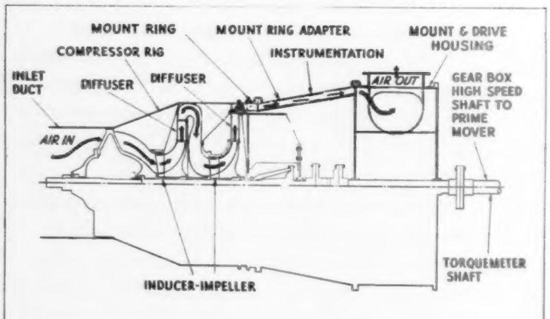

FIG. 7.

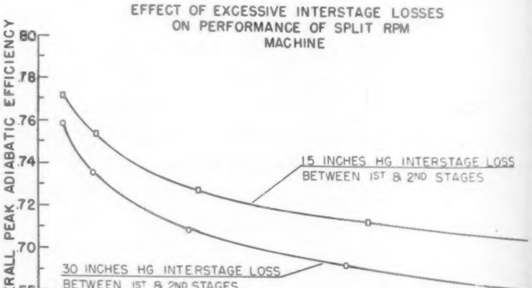

FIG. 10.

without loss in peak efficiency, it is necessary to do further testing of more than one stage to ensure the proper matching of several stages, as well as to develop the interstage passages to the minimum loss figures required for high efficiency. Fig. 7 shows a schematic sketch of such a two-stage rig used at Wright Aeronautical Corporation for developing a two-stage centrifugal compressor.

Development of such a compressor requires a great number of separate tests, as well as considerable test equipment. Fig. 8 shows the 15,000 hp. prime movers used at Wright Aeronautical in developing multistage centrifugal compressors. The stepup gear box and torquemeter installation are shown on Fig. 9.

EFFECT UPON EFFICIENCY OF EXCESSIVE INTERSTAGE LOSSES

The efficiencies given for the multistage machine were based upon an assumed interstage drop of 1.5 in. Hg at sea level and 0 m.p.h., which it was previously stated could only be obtained with considerable development. A series of calculations have been made to illustrate the effect upon adiabatic efficiency of the interstage loss being excessive. In this case the assumption was made that the interstage losses were increased to 3 in. Hg at the sea level and 0 m.p.h. point. Fig. 10 shows the calculated efficiencies obtainable for the two different cases. The calculations were made for the split-speed machine previously discussed. Examination of Fig. 10 shows that at a pressure ratio of 17 to 1 the efficiency is lowered two points from that obtained with the 1.5 in. Hg interstage loss. The efficiency was not only reduced but the overall pressure ratio dropped from 17.4 to 16.5 for the same number of stages. Thus it appears that the attainment of low interstage drop is highly important.

CONCLUSIONS

Summarizing, it is felt that for the pressure ratio range from 10 to 20 to 1 the overall adiabatic efficiencies will be essentially the same for all the various methods of multistage centrifugal compressors. Therefore, it appears that for pressure ratios above 10 to 1 the multistage centrifugal compressor type should be selected on design factors such as number of stages, weight, and complexity rather than overall efficiency.

REFERENCE

[1] Campbell, K., and Talbert, J. E., *Some Advantages and Limitations of Centrifugal and Axial Aircraft Compressors*, SAE Transactions, Vol. 53, No. 10, pp. 607–620, October, 1945.

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The Problem of Stick Force per g*

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Beech Aircraft Corporation

TECHNICAL IMPROVEMENTS in personal light aircraft of the last few years, with an ultimate goal of greater utility, have resulted in increased cruising speeds, higher wing loadings, increased maneuvering capabilities, more versatile trimming devices, and instrumentation for flight in marginal weather conditions. The magnitude and character of elevator forces required to maneuver the airplane through abrupt changes in flight path or in steep turning flight are tangible quantities readily perceptible to the pilot, and they form one standard acceptable index to satisfactory or undesirable accelerated-flight characteristics.

The increment in stick force required to pitch the airplane to a higher angle of attack is directly proportional to wing loading and the product of the elevator span and root-mean-square chord squared. This portion of the force required is also a function of center-of-gravity position, and it diminishes as the c.g. position moves aft.[1] This contribution vanishes for a c.g. location at the stick-free neutral point. The increment in stick force caused by curvature of the flight path is directly proportional to the air density, the tail length, and the elevator span times the square of its chord. This part of the force per g diminishes as altitude is increased; it is independent of the c.g. position.

Desirable Characteristics of Stick-Force Gradient for Light Aircraft

The elevator-force gradients should be comparatively heavy for light business transports where safety rather than maneuverability is the prime necessity. Comparatively small values of stick force per g are desirable on sport and training airplanes where the emphasis is on maneuverability. Low values are required to obtain maneuverability without excessive pilot fatigue, safety being realized in the smaller c.g. range required and in the higher design load factors incorporated.

The "feel" of the variation of control force with normal acceleration is another important consideration. One reference states that there is probably an optimum pattern of pressure increases which would furnish the pilot with a maximum number of discriminable cues.[2] It is further pointed out that, in comparing the magnitudes or changes in force by stick "feel," it is the ratio of the magnitudes of force which is significant and not the absolute magnitude or the arithmetical difference in forces. These statements would indicate a trend of increasing slopes of stick force per g with increasing normal acceleration to furnish optimum "feel" in maneuvering flight. The Beech Model A35, flight-tested with an antiservo tab, provided stick-force gradient data in turning flight which followed this trend.

Stick-Force Gradient Characteristics for the Standard Beech Model A35

Complete flight tests have been conducted in both abrupt pull-ups and in turning flight for a range of trim speeds. These tests were all conducted in the "clean" configuration, gear and flaps up, and with the c.g. position as far to the rear as allowed for the maximum gross-weight condition. A plot of the increment in pull elevator stick force required with normal acceleration in turning flight for a speed range of 150 to 200 m.p.h. shows that the force gradient curve is nonlinear as predicted by theory.

A chart of the stick forces in level abrupt pull-ups, variable with speed and based on stabilized maximums, is shown in Fig. 1. The reduction in elevator force with speed for a constant value of g is probably due to distortion effects of the elevator and possibly due to the entire tail. Test data on other airplanes have in many cases exhibited a similar trend. Nonlinear hinge moments and elevator fabric distortion have also accounted for this reduction. It will be noted that the stick force to pull ultimate load factor at the design dive speed of the airplane (224 m.p.h.) is 83 lbs., while 115 lbs. is required to attain ultimate load factor at the minimum possible speed (accelerated-flight stall). These values compare with a maximum allowable force of 75 lbs. for temporary pilot application during any type of *approved* airplane maneuvering within specified limitations.[3] It is, of course, obvious, as indicated by the above extremes, that the Beech Model A35 was not designed as an acrobatic airplane, the stress being on safety for such possible extremes that might be inadvertently attained. It was generally concluded that the stick forces in accelerated flight for the standard Beech Model A35 are reasonable and safe within the range of its design limitations as a personal transport.

Effects of Configuration Changes on the Beech Model A35

One alteration was the introduction of antiservo actuation into the standard elevator tab system. The tab functioned as an unbalancing agent, with the effect

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* Condensation of a paper presented at the Sixth Annual Personal Aircraft Meeting, I.A.S., Wichita, Kan., April 29–30, 1949.

† Aerodynamics Division.

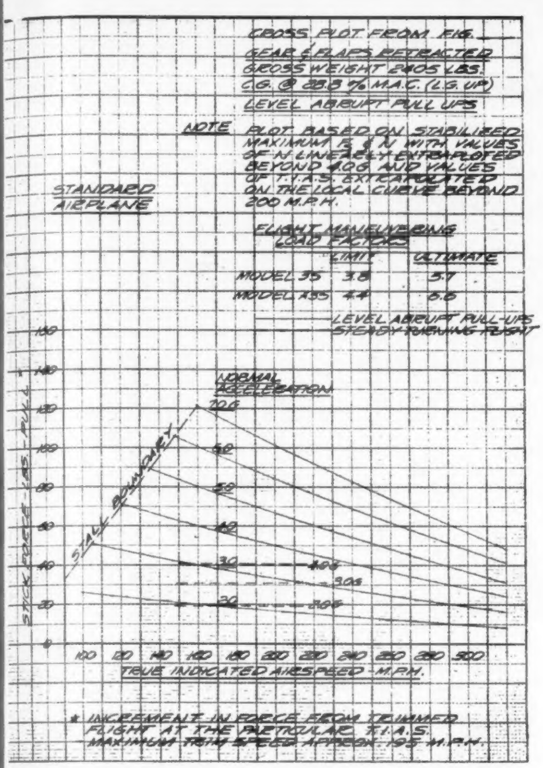


FIG. 1. Stick forces in accelerated flight.

proportional to the amount of elevator deflection. Two antiservo tab ratios, 0.3 and 0.5, were investigated, the ratio being that of tab travel to elevator travel.

A reduction in stick-force gradient in turning flight compared to the standard airplane for $N < 2.0$ may be explained by the fact that the increase in elevator effectiveness due to the effective tail-plane camber increase served to reduce the net hinge moment required to maneuver the airplane to values of N in this range. Somewhat the same explanation applies to the stick-force gradient values for the two antiservo tabs relative to each other. In addition, it is believed that deflections were more severe for the higher antiservo ratio.

As was previously mentioned, the antiservo action provides favorable "feel" at the higher values of N. It is observed, however, that the initial response and centering tendency of the wheel to the stabilized trim position at 1g is inferior to that of the standard airplane configuration.

The increase in stick-force gradient for abrupt pull-ups is also apparent from time-history curves. Approximately the same maximum stabilized values of stick force were obtained at the peaks, while the corresponding values of acceleration decreased in the respective order: standard configuration, 0.3 antiservo ratio, and 0.5 antiservo ratio. The same relationship in this range of N was exhibited as for the turning flight tests, except that the actual stick force per g was higher for the 0.5 antiservo ratio than for the 0.3 antiservo ratio.

The horizontal surfaces of the Beech Model 45 are the identical Model A35 V-surfaces rotated to zero degrees dihedral with respect to the airplane plane of symmetry. This change also produced near equivalent safety for the two airplanes in terms of elevator force required to maneuver the airplanes to limit load factor in turning flight. This value is approximately 42 lbs. for the Beech Model A35 and 47 lbs. for the Beech Model 45 with the critical rearward c.g. location that was flight-tested.

The aerodynamic effects resulting from this change, which was made in order to produce the lower values of maneuvering-flight stick forces, result principally from a reduction in elevator deflections required to maneuver the airplane and from an increase in the elevator "unloading" effect due to angle of attack.

COMPARATIVE FLIGHT TESTS FOR THREE LIGHT FOUR-PLACE AIRPLANES

Turning-flight stick forces were also obtained on the Ryan Navion (1948 model) and the Stinson Voyager 150 (1947 model) by means of a calibrated tension ring and dial-gage system mounted on the control wheel column. Data were read in stabilized flight and recorded by the pilot. The data were obtained at the approximate respective rearmost c.g. position allowable for the maximum gross-weight condition. There was little or no significant difference in turning-flight stick-force gradient for the three airplanes within the limits of flight-test accuracy obtainable. A representative value of acceptable stick-force gradient for the airplanes of this type in turning flight, with an accelerometer used to measure normal accelerations, would be 10 lbs. per g for these critical c.g. loadings.

ERRONEOUS INSTRUMENT FLIGHT PROCEDURES

The attempts of pilots, inexperienced in instrument flying, to fly in instrument weather often have disastrous consequences. Often, extreme maneuvering attitudes in high-speed flight have been the main offenders, by imposing destructive loads on the airplane.

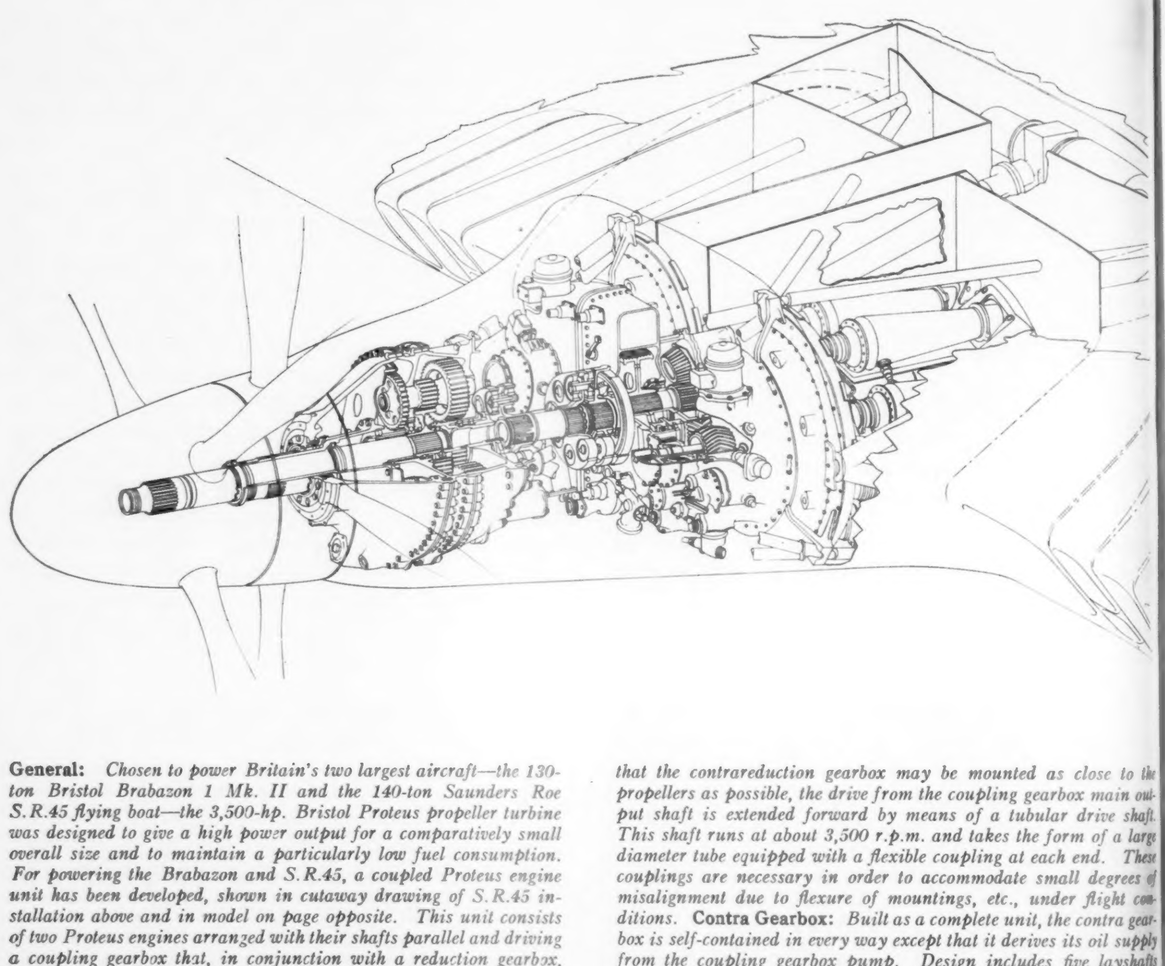
There are two likely predicaments in which the inexperienced pilot may find himself.[5] The first of these is called "chasing instruments," in which the pilot alternately climbs and dives, while the extremes in air speed become larger for each succeeding oscillation. This situation becomes serious when the airplane is trimmed for slow or cruising flight. The stick forces for the trimmed flight conditions of Fig. 1, for example, may be reduced by as much as half if the speed at which abrupt elevator movement is made departs considerably from the trim speed. The normal control "feel" imparted by the increased elevator forces at correspondingly higher normal accelerations may be lost completely in an erratic maneuver of this type. When a light force immediately follows a heavy one (or vice

(*Continued on page 93*)

Aeronautical Engineering Design Trends

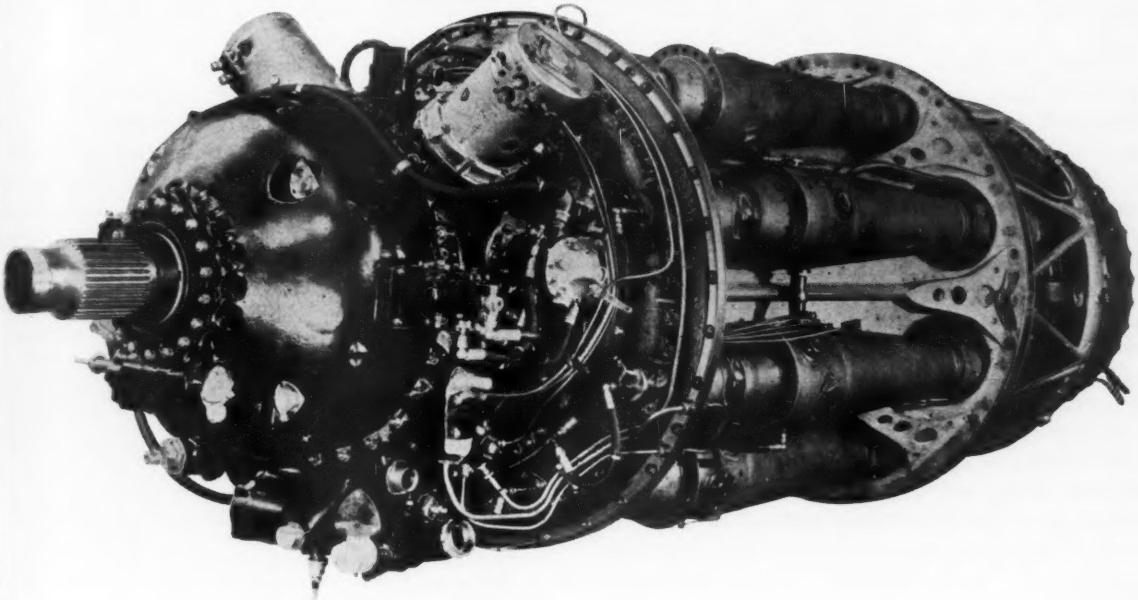
Bristol Proteus Propeller Turbine

Coupled Power Unit Installation

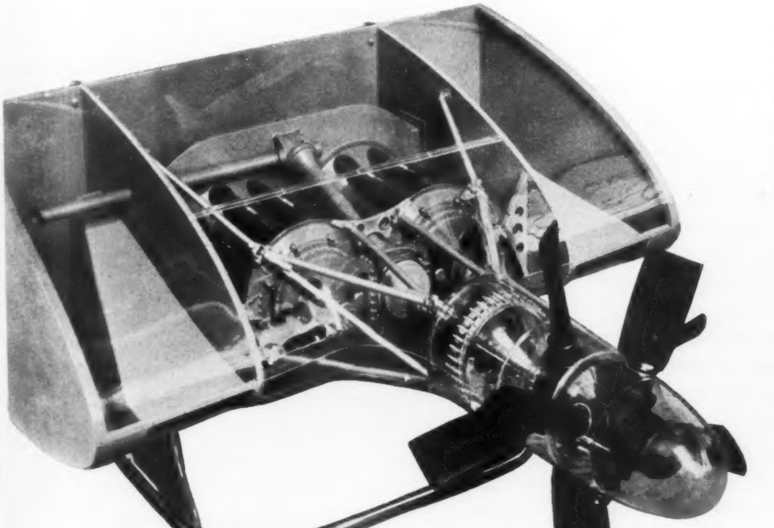


General: *Chosen to power Britain's two largest aircraft—the 130-ton Bristol Brabazon 1 Mk. II and the 140-ton Saunders Roe S.R.45 flying boat—the 3,500-hp. Bristol Proteus propeller turbine was designed to give a high power output for a comparatively small overall size and to maintain a particularly low fuel consumption. For powering the Brabazon and S.R.45, a coupled Proteus engine unit has been developed, shown in cutaway drawing of S.R.45 installation above and in model on page opposite. This unit consists of two Proteus engines arranged with their shafts parallel and driving a coupling gearbox that, in conjunction with a reduction gearbox, drives two coaxial shafts for the contrarotating props. Because of their small diameter, the coupled units are designed for installation entirely within the wing, while the reduction gear and propeller shafts are enclosed in faired stalks projecting forward of the wing. The Brabazon Mk. II is powered by eight Proteus engines arranged in two coupled pairs on each wing, whereas the S.R.45 will have ten, eight of which will be coupled pairs with a single Proteus driving a single prop in the outboard position on each wing.* **Coupling Gearbox:** *The paired turbine units, their centers approximately 42 in. apart, are attached to the coupling gearbox, a large three-part cast aluminum casing housing the first stage of the transmission gearing, together with various ancillary drives. Gear train comprises a double helical pinion driven direct by each power turbine, each meshing with an idler in turn in mesh with a single output gear. Reduction ratio is 3.2:1, and each gear and pinion is supported on ball or roller bearings. Connection between each power turbine shaft and its pinion is via a dog clutch that may be hydraulically disengaged by remote control to isolate a turbine in emergency.* **Primary Drive:** *So that the contrareduction gearbox may be mounted as close to the propellers as possible, the drive from the coupling gearbox main output shaft is extended forward by means of a tubular drive shaft. This shaft runs at about 3,500 r.p.m. and takes the form of a large diameter tube equipped with a flexible coupling at each end. These couplings are necessary in order to accommodate small degrees of misalignment due to flexure of mountings, etc., under flight conditions.* **Contra Gearbox:** *Built as a complete unit, the contra gearbox is self-contained in every way except that it derives its oil supply from the coupling gearbox pump. Design includes five layshafts equally disposed round the common centerline of input and prop shafts. The layshafts are carried in plain bearings housed in spiders or diaphragms forming part of the main gearbox casing. The whole gear assembly is housed in a cast light metal case with a forward extending nose in which are carried the front propeller shaft bearings.* **Propellers:** *An eight-bladed contra propeller, 16 ft. in diameter, is specified for this installation. Pitch control mechanism is hydraulically operated; blades are metal and provided with thermal deicing, energized by the electrical system.* **Air Intake System:** *Air intakes are in leading edge of the wing on either side of propeller stalks. Since air intake is toward the rear of the engines, engine air is led by intake ducts to a plenum chamber that surrounds the air intake of the coupled pair in order to provide a uniform air entry to the engines. The intakes in the wing leading edge are so positioned as to be in direct line with the most effective part of the propeller slipstream. In order to maintain temperature of the engine cell at level consistent with best efficiency, while at same time avoiding dangerously high temperatures, an airbleed is arranged from the main air intake ducts.*

Single Proteus Turbine—Front Three-Quarter View



General: *The compressor of the Bristol Proteus engine is a combined axial and centrifugal unit located in the center of the engine with the combustion chambers arranged around it. Air enters at rear of compressor and traverses the axial compressor before passing through the centrifugal stage and being delivered to the combustion chambers. The reversal of airflow direction from forward through the compressor to rearward through combustion chambers reduces length of engine considerably. Hot gases then pass through the turbines that drive the compressor and prop. Noteworthy feature of the Proteus is the mechanical separation of the compressor and propeller turbines, sometimes referred to as a "free-turbine" arrangement. This results in a great simplification of the propeller system and makes engine starting much easier, since a much smaller starter motor may be used.* **Leading Particulars:** *Overall length is 99.75 in. (exhaust cone removed); overall diameter, 38.5 in.; weight net (dry), 2,900 lbs.; center of gravity, 18.5 in. forward of mounting ring aircraft attachment face; fuel, aviation kerosene (specific gravity 0.81); oil Intava 7117 type "B" (60-sec. viscosity); propeller type, feathering and braking; propeller shaft size, S.B.A.C. No. 6—R.S. 267; propeller rotation, L.H. tractor; turbine/propeller reduction gear ratio, 11.11:1; compressor r.p.m., 10,000 maximum; sea-level static power, 3,200 s.hp. plus 800-lb. thrust.*



Mounting: *The paired turbine units are attached by means of the steel centrifugal compressor housing and turbine accessory housing to the coupling gearbox. A rigid unit is thus formed which at once unites the two turbine units and forms a convenient member by which the whole power plant is carried. A triangulated tubular structure (see cut at left) extends forward, carrying the contra gearbox. The complete power plant, forming one assembly, is secured to the wing by attachments picking up at left and right of the subunit above mentioned. The attachments are so designed as to accommodate all shear and yawing loads. Nodding loads are accommodated by means of struts attached to the four extremities of the gearbox subunit and extending rearward to points on the nose ribs at or near to the main spars. The main attachments to the aircraft are designed to accommodate expansion of the gearbox in a lateral direction, thus avoiding transmission of stresses from thermal causes, to the aircraft structure.*

Paired Proteus Unit Model

Atomic Power

(*Continued from page 21*)

such a stockpile we might have a chance for diversions to power for civilian uses. Again we have a challenging goal, and, unless we have lost our zest for adventure, it is a goal from which we will be deterred only by a convincing demonstration of its scientific impossibility.

If reactors are so desirable, why don't we go ahead and build some? Now we come to the difficulties! Here are a few of them:

(1) For any reasonable thermodynamic efficiency in utilizing the great energies available, it is necessary to operate at temperatures well above the conventional engineering range.

(2) The compactness of reactors, which is an important inherent advantage, proves troublesome with regard to the heat-transfer problems that involve heat-transfer rates far transcending previous experience.

(3) The materials chosen for the reactor must withstand not only high temperatures but also high nuclear radiation densities, with unpredictable changes in the physical properties of the materials concerned. The seriousness of this problem can perhaps be visualized by this kind of comparison. How would you like, for example, to design airplanes or engines if, in use, the properties of the aluminum and steel would gradually change to those of cast iron or lead?

(4) If we finally find a structural material for reactors which appears suitable as far as physical properties are concerned, we must now add still another requirement. The nuclear properties must be such that the structural material will not capture neutrons and thus deplete the supply and reduce the power. This requirement drives us to consider strange new elements and raises a whole array of procurement problems.

(5) Even after we have our reactor working, we find that the fission products produced as an essential part of the reaction "poison" the reaction itself. The ashes smother the fire. Now you gentlemen are well aware of the enormous maintenance problems for aircraft engines. Every 800 hours they must be disassembled, inspected, have defective parts replaced, and then reassembled and tested. The work is staggering. However, how would you like it if, instead of merely disassembling, the entire engine would have to be dissolved in nitric acid and the rebuilding of the engine started with getting a solution of certified chemically pure iron? This is the fuel reprocessing problem!

(6) Finally, assuming we have solved the structural problems listed above, we have a whole new category of problems in connection with the working fluid or heat-transfer medium used to convert the heat into power. The nature of these problems can be suggested by the fact that from rough comparisons of the volumes of reactors and the present highly perfected aircraft engines, the rates of heat transfer must be more than an order of magnitude greater for nuclear reactors than for conventional engines. Orthodox advances will not be sufficient. The problems involve the use of liquid metals with all the associated corrosion, erosion, purification, and pumping troubles we can readily imagine as being associated with those elements that appear to have suitably low melting points.

When one considers the host of difficulties and troubles that lie in the road ahead in the development of atomic power the problem does look formidable. I am reminded of a statement made a little over 100 years ago by the great chemist, Wöhler, with regard to the status of organic chemistry at that time. Wöhler wrote to Berzelius as follows:

> "Organic chemistry just now is enough to drive one mad. It gives me the impression of a primeval tropical forest, full of the most remarkable things, a monstrous and boundless thicket, with no way of escape, into which one may well dread to enter."

That is an excellent description of the atomic energy field right now, in 1949! In the meantime, however, what has happened to organic chemistry? Well, newspaper headlines give the answer. Miracle drugs are practically tailor-made these days. DDT and 2-4-D are taken for granted by the farmer. Synthetic rubber threatens to displace the natural product. One hundred years from now what will be the status of atomic energy? Who now has the wisdom to predict either failure or success?

We can all hope for the era of free power and effortless living usually associated with the Atomic Age. This implies the successful development of large, land-based, electric power-producing reactors. We have also heard discussed the military advantages that might be gained by nuclear propulsion of ships and aircraft. I will discuss these in more detail later, but the point I want to make now is that, whereas the technical problem would be least in the land-based power reactor and progressively more difficult in the ship and aircraft reactors, the present urgencies or priorities are just the other way around. Perhaps fortunately, however, the same ground must be covered in the initial stages whether the ultimate purpose is for civilian or military use. We might take as an analogy, a transcontinental journey, starting from Washington in the frontier days. Whether the ultimate goal was Oregon or California, the route was the same through Cumberland Gap and on to St. Louis. To complete our comparison we might put civilian power in California and military power in Oregon. These are the things we dream about. At the moment we are really only approaching Hagerstown, and our worries and our plans are all concerned with surviving the hazards of the journey to St. Louis.

I do not need to stress before this group the importance of the incentive given to technical developments by military needs. This group is well aware—I might even say painfully aware—of the vicissitudes of the development of the airplane to the highly perfected state in which we have it today. Similarly, in the atomic power field it appears that military needs will have to provide the incentive to carry through difficulties for progress, even though ultimate dividends may be expected in the civilian economy.

Going further back into history, we can cite the difficulties of converting ships from wood to steel. Again, the incentive was military, but note this quotation:

> "Early experiences with iron as the material for hull construction were far from reassuring. In England where several iron warships had been completed by 1846, firing trials conducted in 1845 and in 1850 indicated that 32-pounder and 68-pounder shot striking iron plating were likely to break up and form more splinters from the shot themselves and the iron of the target than were caused by the impact of the same shot upon wooden targets. Accordingly, the British Navy pronounced iron to be an unfit material for hull construction."

Only if both the opportunities and the difficulties in the field of atomic energy are fully appreciated can the history of the atomic developments over the last several years be understood. This is a field in which the experts disagree. The more distinguished they are, the more violently do they disagree. (At this point, I want to disqualify myself as an expert. Scientists live and work in laboratories, not in marble buildings in Washington! I am an ex-scientist now. My job is to be a good listener and an accurate interpreter.) When experts disagree, a middle of the road course of action is indicated, and this indeed is what we have in the Commission's Reactor Development Program.

As has been announced and as presented in Budget hearings before Congress, so there are no security questions involved, the Commission program consists of two main parts. The first is a strong applied research program seeking to establish the basic facts—the handbook data if you like—which will ultimately be needed in solving the reactor design problems. For the reactor program, the center of this type of authority is at the great Argonne Laboratory at Chicago.

Because of the foresight of the Manhattan District and its advisers and the continuing generous support by the Commission and Congress, the nation has an exceptionally well-supported predominantly nonmilitary applied research program in the atomic energy field. In the large national laboratories we have thousands of people working on and becoming acquainted with atomic energy problems. In our atomic energy production plants we have thousands more. These people are our standing army, mentioned above as requirement No. (2), and our preparation for any eventuality of the so-called Atomic Age.

But it will take more than the accumulation of a library full of knowledge to get power-producing reactors. We have 40,000,000 automobiles on the roads of the United States, but we still do not "understand" the mechanism of combustion. It is for this reason that the second part of the Commission's program is the engineering development and construction of a series of definitely experimental prototype reactors. These represent assignments to specific task forces as mentioned in requirement No. (3).

Of course, the nation has had reactors of various kinds, from almost the beginning of its atomic energy program. The famous chain reacting pile at Chicago was the first of such reactors. A series of reactors was built during the war, culminating in the huge single purpose production reactors at Hanford. Other reactors have since been built, but these are, by and large, research type of reactors, small in size, and none of them capable of producing useful power in appreciable amounts. The next phase in the historic development of reactors calls for designing and constructing of reactors that are larger, more complicated, and more difficult to build than any we have produced thus far. As in any new technical development, there are many uncertainties and many risks involved. It is here that the experts disagree on details of designs of reactors that will do the jobs that need to be done. Largely, for this reason, in the 4 years since the end of the war, no really new or greatly improved versions of reactors have been built in this country. The reactor of most advanced design and performance is in Canada.

The proposed reactor development program of the Commission crystallized out of the 4 years of discussion and argument, as well as from new knowledge gained from the applied research program since the end of the war. Reactors can conceivably be used for a wide variety of purposes. Special reactors of many types have been proposed by responsible people for purposes varying from small compact units for propelling guided missiles to huge stationary power plants for providing cheap electric power for supplying our great cities and distilling ocean water for irrigating our deserts. To the people most fully informed, it is clear that the difficulties of building any reactor are so great that only a few projects can be adequately supported with money and, particularly, with competent technical man power at the present time. It is for this reason that it is essential from the multitude of possible reactors, only a few carefully selected projects should be chosen, and strong technical support should be focused on these few.

Getting back to the fundamentals, a reactor can be made to produce two things: a large number of neutrons and a large amount of heat or power. At Hanford, in the production reactors, the neutron supply is utilized for the conversion of the nonfissionable U-238 into fissionable plutonium for use in atom bombs. In the existing Oak Ridge reactor, again the neutrons are used for the production of isotopes for peacetime research purposes. In both cases, the heat generated is wasted—it is lost in water coolant at Hanford and in air coolant at Oak Ridge. At the present time, there are no reactors in existence so designed that the heat produced can be made to serve useful purposes.

An obvious forward step would be the design of a reactor in which the neutrons produce fissionable materials as in the existing production reactors, but, in addition, the heat generated is put to work. Unfortunately, scientists and engineers at present do not have enough basic knowledge to design such obviously desirable reactors. Their first step would appear to be to produce a reactor specifically for the single purpose of generating large amounts of heat at temperatures that will permit conversion to power. So extensive is our ignorance, however, that even such a simplified design is forcing us into pioneering activities beyond the present boundaries of human knowledge. Before any reactor can be built with a performance appreciably better than those we now have, a large amount of applied research in specialized fields is necessary. This is the activity with which our laboratories have been preoccupied for the last 4 years.

We are now at the stage where, if we intend to progress further, it will be necessary to find the courage to build a few reactors to test what we think we know. The reactors in the Commission's program are essentially experimental prototypes. None of them can be described as an "end-item" that will drive an airplane or a ship or power and light a city. Further generations of reactors will be required before such desirable goals can be attained. It is this fact that sets a time scale of 10 to 20 years before useful and economical civilian applications of atomic power can be expected. However, if the ultimate goal is ever to be attained, the first steps must sooner or later be taken, and it is these first steps with which we are concerned in the present reactor program.

As described by Dr. Robert F. Bacher, former Commissioner and a moving force in reactor development work, the current program consists of four reactors:

(a) The first of these has been designated as a materials testing reactor. We call it "MTR." While it is itself an experimental reactor, as its name implies, it is intended also to give information on the behavior of materials in reactors so that larger and more powerful special purpose reactors may ultimately be built. This reactor is of particular interest to the Air Force, since it represents the boldest step into the unknown which we now dare to take, moving in the direction of compact, high radiation density reactors that must ultimately be developed if the Air Force needs are to be satisfied.

(b) The second reactor is a land-based prototype of a reactor for use in propelling naval vessels. It would be a simple, single-purpose reactor designed specifically and solely for the purpose of producing large amounts of heat under conditions that will permit conversion to propulsive power.

(c) The third reactor is a single-purpose experimental reactor designed specifically to give us information about the breeding process. This reactor at the present time is the most likely to demonstrate the actual breeding of new fissionable material. It is, however, neither a high-power reactor nor is it designed for the purpose of demonstrating appreciable amounts of useful power, though an incidental amount of power may be produced by a by-product.

(d) The fourth reactor is the more ambitious project—the Knolls Atomic Power Laboratory Reactor. This reactor is intended to produce a really significant amount of electric power. At the same time, it is hoped that this reactor will be able to demonstrate at least partial success in breeding. This reactor is, therefore, an extremely complex device, since its design represents a compromise between the demands for power production and for breeding. If successful, however, this reactor would represent a major step forward in the direction of the production of useful power without depleting, and perhaps even increasing, our national supply of fissionable material for any purpose.

Whether by accident or by design, this program is a reasonable middle of the road program. It represents a balance between reactors contributing to the solution of military and civilian problems, a balance between reactors that use up fissionable material and reactors that promise to replenish or increase our national supply of fissionable material, a balance between a bold attempt to solve immediate problems by the engineering approach as in the Navy reactor and the intermediate breeder and the more long-term research approach of gaining more information about the behavior of materials under novel but controllable conditions as in the materials testing reactor and the experimental fast neutron breeder.

I would like now to comment on the fourth requirement mentioned above and which was concerned with getting value received for money invested. How does one put a money value on any new developments, particularly on one of a military nature? What, for example, would have been the value of the "Merrimac" to the South had not the "Monitor" come along? What was the value of the "Monitor" to the North in 1862 dollars? If we want to be modern, what was the value of the Spitfire in the Battle of Britain, or what is the current value of an atomic bomb?

We have heard much discussion recently of the cost of producing atom bombs, but what are they really worth to us—in dollars? It would be helpful to have at least a rough estimate of the present value of an A-bomb, either in dollars or in equivalent divisions or battleships or air groups. While this may sound difficult, order of magnitude engineering estimates to keep our thinking straight are not too hard to make.

We know, for example, that at the end of the war our daily war expenses were approaching $300,000,000 per day. If the A-bombs shortened the war by even 10 days, the entire $2,500,000,000, cost of the Manhattan effort, can be written off and recorded as a spectacular success and a *value*, as contrasted to *cost*, of at least $1,500,000,000 each to set on the Hiroshima and Nagasaki bombs.

Since warfare seems to be mainly a competitive destruction, we can get another estimate in an entirely different way. Taking the radius of destruction for a bomb as from 1 to 2 miles, the area destroyed would be approximately 6 sq. miles. In an average city the property value runs perhaps $50,000,000 per sq. mile. The destruction per bomb, therefore, represents about $300,000,000 and gives a figure of the "advantage" to us, and therefore of the value to us in this insane competition in destructiveness.

We can approach the problem in another way to get another independent estimate. I have heard that a man by the name of Churchill, who seems to have a reputation in these matters, has stated that, but for the A-bomb, World War III would have been under way. Now for those who know how many bombs we have, it should not be too difficult to pro-rate the annual estimated cost of this war among the bombs on hand.

Finally, let us approach the problems in still another way, using an infantile form of operations research. We have been told that one A-bomb is equivalent in effect to 20,000 tons of TNT. Since big, single bursts "overkill" at the center, let us cut this by some suitable factor, say 10, for example. Now one of our large bombers can carry a pay load of about 10 tons, therefore, to carry 2,000 tons would require 200 planes. This is unassailably accurate arithmetic! Large bombers cost half-a-million dollars to build, but with logistic support, more like $2,000,000 in combat. One A-bomb makes one bomber the equivalent of 200. Ergo, one bomb is "worth" $400,000,000.

There is another conclusion that can be drawn from this quick operations research calculation. We should think twice or maybe even three times before permitting too casual diversions of material from the stockpile, even for other conceivable military uses. It follows also that civilian power will remain "pie in the sky" unless, by a "break" in the breeder program or some other solution to the raw material problem, a more ample supply of fissionable material can be provided. Finally, it follows that this is indeed a game in which, if we are to play at all, we play with "blue chips."

In the reactor field what would the nuclear-powered air equivalent of the "Merrimac" be worth in a future contest against a fleet of chemically-fueled airplanes? What would a nuclear-powered naval vessel be worth in a future engagement if it were—as the "Merrimac" and "Monitor" were—one whole generation ahead of the conventional fleets of the day? What would be the value to the nation if, as has been suggested, atomic energy could be used to evaporate sea water to make the deserts bloom? These are the really fundamental questions, and I am glad that it is Congress' responsibility and not mine to make decisions on them. It is, however, my responsibility to see that we get value received out of each dollar appropriated for the reactor program, and this will require more than anything else that effort be kept commensurate with both priority and promise.

I would like, therefore, in view of its special interest to this group, to return to the aircraft propulsion reactor to consider it more in detail. To this group, fully aware of the serious limitations of chemical fuels, I feel sure that the desirability of an ideal nuclear power plant for aircraft is obvious. I can, however, quote a Congressional report on the subject. In the Brewster report we find the following statement:

> "In the event of war or in any international situation likely to lead to war, nuclear energy for the propulsion of aircraft would be comparable in significance to the atomic bomb itself. Presently known limitations inherent in all chemical fuels make difficult the delivery by air of atomic bombs against a distant enemy. Therefore, if the United States had nuclear energy propulsion in addition to atomic bombs, it would be the dominant factor in maintaining world peace. Until these ends are attained, the United States must depend on military weapons and techniques currently available."

With the desirability of an ideal solution to this problem there is general agreement. There is agreement, too, in regard to the contention that developing any kind of an aircraft reactor will be extremely difficult. The NEPA Project, carried out by the Fairchild company under an Air Force Contract, has been engaged in a vigorous attack on this problem since 1945. North American Aviation and the RAND Project have also made important contributions. These studies all seem to indicate that, granting the difficulties of the reactor problem itself, the power conversion problem represents a challenge of almost equal magnitude.

As seems to be characteristic of this field of activity, anything that is obviously desirable and important seems to be almost incredibly difficult. To help resolve the impasse, the Commission last year made a contract with the Massachusetts Institute of Technology to make a study of the problem and to come up with recommendations. The result of this study was the Lexington Report, the details of which are at present properly highly classified.

The immediate course of action indicated in the Lexington Report is essentially that the aircraft propulsion project should be continued in an intensive study phase, both theoretical and experimental, for the next 2 or 3 years, by which time it might be hoped that data might become available to permit a re-evaluation and a more decisive conclusion. It is recognized that this study phase should be made national in scope to include the N.A.C.A. and A.E.C., as well as the National Military Establishment.

These are eminently sound guideposts, and they are being followed. An Ad Hoc Committee, consisting of representatives of the Air Force, Bureau of Aeronautics, N.A.C.A., and A.E.C., has been meeting since last January to coordinate the work of the various Government agencies involved and to ensure an industry-wide approach to the technical problems. In such a joint attack on a problem, clearly, there will be some duplication that must be eliminated and some shifts of emphasis which somehow must be consummated. Committee procedures grind slowly, but this work is well under way. Many of the companies represented here tonight have recently contributed technical talent to the national effort now being organized.

In the meantime, in accordance with the Lexington Project recommendations, the N.M.E. has been asked to evaluate the military worth of the proposed weapon if and when it is produced. This is a really tough assignment. It is indeed controversial, but not in the sense of an interservice feud. This is definitely not an Air Force vs. Navy issue. Both the Air Force and the Bureau of Aeronautics want nuclear-powered airplanes if at all possible, and so long as the Atomic Energy Act is in existence neither can hope to build a private empire in this field even if it so desired. The issue, and the controversy are really fundamental. They rest on the typical, perplexing, circular, hen and the egg, nature of all the decisions involving new weapons which the military are continuously asked to make. How valuable nuclear-powered aircraft might be depends heavily upon when it will be available, what the maintenance problems are, what the cost will be in diversion of fissionable material, not only for the aircraft reactors installed but also for the inventory required by the complex reprocessing procedures required for nuclear fuels. Unfortunately, the answers to these questions depend on the priority that is attached to the development program. How soon nuclear-powered aircraft can be available depends on how much effort we put into the program. Similarly, how soon we can give information as to probable performance and costs will depend on how rapidly the work progresses. The dilemma is real and serious. It was to aid in solving just such problems that the Weapons Systems Evaluation Group, under General Hull, was set up in the National Military Establishment.

The best summary of the situation which I can give is that the pessimists, who in general are those best informed, have thought through the immediate reactor and power-transfer problems and are staggered by the maintenance and operations problems that would be involved if the actual aircraft propulsion devices for combat use were to be based on our present knowledge and practices. The optimists, on the other hand, either are not yet aware of the real immediate difficulties or they are betting heavily on new ideas and new developments arising during the course of the work which avoid some of the currently foreseeable troubles. In this connection, I seem to recall, however, that not many years ago all the technical facts and all the arguments of the experts indicated an upper limit of 100,000 lbs. as an absolute ceiling for the size of heavier-than-aircraft. This is an area in which it will no doubt be wise for us to be open-minded but skeptical. The best we can hope for in a program such as this is one in which the best available advice is sought and used.

In my introduction I raised the question as to whether our objective was worth while and whether we had a sound approach. Let me now try to summarize the situation as it looks at the present time.

We want to maintain technical leadership in the atomic energy field. This is our objective and our assignment by Act of Congress. As part of this effort we want a vigorous reactor program. This program must earn its keep for either peace or war purposes. The initial part of this program is the same whether the ultimate use of the reactors developed is civilian or military. We have a generously supported applied research program in the large national laboratories to give us basic information for new developments and to provide a trained cadre of specialists in the atomic energy field. We have engineering task forces attacking some of the most promising possibilities available to us at the present time. Most urgent are the two premium fuel uses of interest to the military—namely, power for ships and power for aircraft. The first of these, while difficult, can conceivably be attained by direct frontal attack. The second is being attacked indirectly with the Materials Testing Reactor, representing an important, exploratory advance, as well as providing an almost essential research tool. The M.T.R. will be to reactor development what wind tunnels are to aircraft developments.

Another strong task force is engaged in a difficult but promising assignment on a reactor that can either be considered as giving power with fissionable material as a by-product or fissionable material with power as a by-product. In either case success would represent a major step in advance toward economical power for either military or civilian use.

The fourth task force is engaged in a frontal attack on the problems presented by the chronically short supply of fissionable material. Ideal success would increase by a factor of 139 the potential stockpile of fissionable material and might bring atomic energy for civilian use within sight. Even partial success might go far toward helping us increase the efficiency of present production processes.

Success in all of these task force efforts is probably too much to hope for, but the possible return in each appears high enough so that success in one will pay for the rest. The risks are great but the stakes seem greater.

Details of the program are controversial, and on these it is undoubtedly discreet for me to maintain a studied silence. I might be permitted, however, to end with a quotation from one of the wisest of scientists, Benjamin Franklin, which dates from the year 1780:

> "The rapid progress true science now makes, occasions my regretting sometimes that I was born so soon. It is impossible to imagine the height to which may be carried, in a thousand years, the power of man over matter. . . . Oh that moral science were in as fair a way of improvement."

I.A.S. Briefs

Summaries of current papers accepted for publication or presentation at I.A.S. Meetings

A Modification of the Holzer Method for Computing Uncoupled Torsion and Bending Modes

By

Henry E. Fettis

Air Materiel Command

The present method is an adaptation of the well-known process devised by Holzer for solving the differential equations of beam vibrations. Several versions of this method are now in common use; the original form is described in references 1 and 2 and is usually employed in computing the torsional modes of vibration of a bar carrying a series of concentrated discs. Similar processes were devised by Myklestad and Bellin for bending modes, and recently an extension of the above principle to the computation of coupled modes has been published. All of the above methods have in common the feature that a value of the frequency is assumed and a deflection computed which satisfies all but one of the required end conditions. Although the same principle forms the basis for the following method, the system of numerical integration employed makes the method better suited to configurations with continuous mass and stiffness distributions. The process is set up in such a manner as to be easily adapted to routine calculation by a semiskilled computer, and the correctness of the results may be verified at each station. All of the features that make the Holzer method practical are retained, and some new techniques not in common practice are introduced.

A Solution for the Lift and Drag of Airfoils with Air Inlets and Suction Slots

By

C. B. Smith

United Aircraft Corporation

The general airfoil theory is extended to cover the case of airfoils having air inlets and suction slots. The analysis, employing formal potential theory, rests on the usual assumptions of an incompressible, nonviscous fluid satisfying the Kutta condition. Subject to these assumptions it is found that the lift and drag of such an airfoil are given by:

$$C_L = 2\pi(\alpha + \epsilon) + 2 \sum_n C_{Q_n} \tan\left(\frac{\beta_n - \epsilon}{2}\right)$$

$$C_D = 2 \sum_n C_{Q_n}$$

where the symbols are defined on Figure 6.

Please do not order Preprints of these papers at this time.

See page 51 for Preprints that are immediately available.

These results indicate that an air inlet or suction slot on the upper surface, $+\beta$, increases the lift or, on the lower surface, $-\beta$, decreases the lift in a manner analogous to changing the camber of the airfoil. An air inlet near the nose, $\beta = 0$, is indicated to have no effect on the lift, while a suction slot on the upper surface, or the equivalent of a source on the lower surface near the trailing edge, are indicated to give large lift increments. The latter arrangements are considered to be of possible interest as a control or high lift device. All of these effects are hydrodynamic and independent of the effect of the inlet or slot on the boundary layer.

Temperature and Velocity Profiles in the Compressible Laminar Boundary Layer with Arbitrary Distribution of Surface Temperature

By

Dean R. Chapman and Morris W. Rubesin

National Advisory Committee for Aeronautics, Moffett Field, Calif.

An analysis is presented which enables the temperature profiles, velocity profiles, heat transfer, and skin friction to be calculated for laminar flow over a two-dimensional or axially symmetric surface without pressure gradient but with an arbitrary analytic distribution of surface temperature. The general theory is applicable to a gas of any Prandtl Number, although the numerical results given herein have been computed for air ($Pr = 0.72$). The predictions of the theory for the special case of constant surface temperature are compared with the calculations of Crocco. On the basis of this comparison, it is inferred that the present theory enables heat-transfer and skin-friction calculations accurate to within about 5 per cent to be made for flight conditions up to Mach Numbers near 5 and to within about 1 or 2 per cent for supersonic wind-tunnel conditions up to considerably higher Mach Numbers.

A particular effort has been made to present the results, which are quite simple considering their generality, in a form that can be used readily in practical applications. From the mathematical point of view the theory is applicable to an arbitrary analytic distribution of surface temperature, but in any given practical case it is necessary that the surface-temperature distribution be approximated by a polynomial. The only unknowns in the final equations developed are the coefficients of this polynomial, so that the work involved in applying the theory in any given case depends entirely on the work involved in approximating a given surface-temperature distribution by a polynomial.

An example is worked out in detail which illustrates some of the principal effects of variable surface temperature. It is shown that both positively infinite and negatively infinite heat-transfer coefficients can occur. The anomaly of infinite and negative heat-transfer coefficients is discussed and is attributed to the customary definition of the heat-transfer coefficient which is shown to be fundamentally inappropriate for flows with variable surface temperature. In the particular example considered, a conventional method for calculating the net heat transferred yields completely incorrect results. A brief qualitative discussion of the possible effects of the heat transfer on flow separation is given. In order to facilitate the use of the results, all of the principal equations developed are collected and summarized in one section.

Aerodynamic Hysteresis as a Factor in Critical Flutter Speed of Compressor Blades at Stalling Conditions

By

Alexander Mendelson

Lewis Flight Propulsion Laboratory, N.A.C.A.

As part of the study being made at the N.A.C.A. Cleveland laboratory on the flutter of compressor and turbine blades, a theoretical analysis was made of the effect of aerodynamic hysteresis on stalling flutter. The assumption was made that the absolute magnitude of the oscillatory aerodynamic forces and moments is the same at stall as at zero angle of attack but that the vector magnitudes of these forces and moments are changed, this change being caused by the lag of aerodynamic damping and restoring forces behind the velocities and displacements at stall, thus giving rise to a hysteresis effect. The decrease of critical flutter speed at stall was thus theoretically shown. The results were applied to a given airfoil, and correlation of the experimental and theoretical results was found possible by assuming that the angle of aerodynamic lag varies as the slope of the static-lift curve. The aerodynamic lag was shown to cause the effective torsional damping to decrease, thereby explaining the low values of torsional aerodynamic damping obtained at stall.

Heat Transfer in Laminar Compressible Boundary Layer on a Porous Flat Plate with Fluid Injection

By

Shao Wen Yuan

Polytechnic Institute of Brooklyn

A theoretical investigation was made of flow of hot fluid over a porous flat plate under the condition of uniform fluid injection from the bottom of the plate. von Kármán integral relation of the momentum equation was derived with the uniform velocity of injection taken into consideration. The velocity profile was assumed as a polynomial of the fourth degree.

Solution of the above equation gave the relationship of length in the direction of flow to the boundary-layer thickness. The velocity profiles and the temperature profiles were then calculated for a Prandtl Number equal to unity.

The relation between wall temperature and the rate of coolant injection was calculated for different Mach Numbers, Reynolds Numbers, and viscosity variation with temperature.

Matrix Solution of the n-Section Column

By

William T. Thomson

University of Wisconsin

A procedure is developed for the determination of the critical load of a column of n different sections under any end conditions. When n is a small number, the method leads to simple analytic expressions for the critical load.

Simplified Analysis of General Instability of Stiffened Shells in Pure Bending

By

F. R. Shanley

The RAND Corporation

Although much work has been done to develop a theory for the failure of shells by general instability, there is at present no simple method by which the size of the frames may be determined for any given diameter, bending moment, and frame spacing. Such a method is needed in determining the optimum design for stiffened shells, to be used as a basis for weight analysis of fuselages, and other shell structures. In an extension of the work done for The RAND Corporation a simple coefficient has been determined for this purpose. Since it appears that this method may also be useful in design calculations, a brief description is presented herein.

Mixing of Any Number of Streams in a Duct of Constant Cross-Sectional Area

By

Roger Weatherston

Cornell Aeronautical Laboratory, Inc.

A one-dimensional analysis is applied to the mixing of any number of streams of a compressible gas in a duct of constant cross-sectional area. By the proper selection of significant parameters and by the use of convenient functions, the solution of the problem becomes simple and brief.

The Optimum Proportions of a Multicell Box Beam in Pure Bending

By

Herbert Becker

Edo Corporation

Employing a method similar to that used for long unstiffened circular cylinders in pure bending, a theory is developed which shows that there is an optimum chord for a multicell box beam of specific structural thickness ratio resisting a constant moment. The theory, utilizing the secant modulus for plastic buckling of the compression cover, assumes that cover buckling constitutes failure. This assumption is applicable to highly stressed wings found on transonic and supersonic aircraft.

A simplified calculation procedure is included for rapid design purposes.

The investigation reveals that: optimum cross-section proportions require a web spacing equal to the box depth; any box designed to fail at a stress in the neighborhood of the yield point will be close to the optimum design; and the optimum stress for a multicell box beam in pure bending is approximately the same as for a long unstiffened circular cylinder under the same loading.

Basic Studies on Flame Stabilization

By

Glenn C. Williams

Massachusetts Institute of Technology

This is a report of initial studies to determine the mechanism of anchoring flame in high-velocity air-fuel streams. Simple bluff shapes were used as flame stabilizers in a constant area 1- by 3-in. rectangular duct carrying homogeneous mixtures of air and gaseous fuel. The limiting gas velocity above which flames blew off the stabilizers was studied as it was affected by:

(1) The approach gas stream variables.
  (a) Fuel-air ratio (over the whole range of inflammability).
  (b) Turbulence (intensities from 0.3 to 4 per cent of the approach stream velocity).
  (c) Fuel type (commercial propane and city gas).
(2) Stabilizer variables.
  (a) Size (characteristic dimension from 0.02 to 0.5 in.).
  (b) Shape (simple, faired, and shortened rods; flat plates; gutters; spheres).
  (c) Addition or extraction of heat from stabilizer.

On the basis of experimental evidence, the following conclusions were reached:

(1) Flame stabilization behind bluff obstacles depends on the presence of a recirculating eddy region that is filled with hot combustion products and furnishes continuous ignition to the approaching unburned gases.
(2) Over the range of stabilizer sizes studied, the blowout velocity under steady flow conditions was found to be affected primarily by the properties of the approach gas stream and the stabilizer thickness.
  (a) For span-thickness ratios greater than 2, the blowout velocity at a given air-fuel ratio in the absence of approach stream turbulence was independent of the stabilizer shape and proportional to the thickness to the 0.45 power.
  (b) For span-thickness ratios less than 2, the corresponding blowout velocity was roughly proportional to the first power of the thickness.
  (c) The stability limits for a stabilizer of given characteristic dimension are unaffected by variation (simulated) of ratio of chamber width to stabilizer thickness over the range 10 to 80.
(3) Increasing turbulence in the approach gas stream decreased both the velocity and air-fuel ratio ranges over which flame could be maintained. The effect of imposing turbulence of a given scale and intensity diminishes with increasing ratio of stabilizer thickness to turbulence scale.
(4) Heating the stabilizer other than by the flame markedly increases the stability limits, and externally cooling the stabilizer markedly decreases the stability limits.
(5) The maximum blowout velocities occur with slightly leaner than stoichiometric mixtures of city gas (26 per cent H_2) and richer than stoichiometric for propane. This is attributed to the different ratios of molecular diffusivity to that of air for the two fuels.
(6) Flame blowoff usually proceeds stepwise, flame propagation throughout the main stream, ceasing before the eddy zone behind the stabilizer is quenched.

Present Status of Research on Boundary-Layer Control

By

A. E. von Doenhoff and L. K. Loftin, Jr.

National Advisory Committee for Aeronautics

A survey has been made of the present status of research on boundary-layer control and its possible applications in aeronautics. Although the number of possible applications of boundary-layer control is large, only those that have received the most attention recently or show the most promise of producing useful results are considered in the present paper. The possible applications of boundary-layer control considered are:

(1) Reduction of profile drag by the elimination of turbulent separation and by increasing the relative extent of laminar flow.

(2) Increase of the maximum lift coefficient through control of laminar and turbulent separation.

(3) The use of suction and blowing slots near the trailing edge of an airfoil as a means of lateral control.

(4) The use of boundary-layer control as a means of increasing the efficiency of diffusers and bends.

(5) The use of boundary-layer control to influence shock boundary-layer interaction at high speed.

The possible improvements in airplane characteristics resulting from these applications of boundary-layer control are discussed, and the general lines of future research are indicated.

I.A.S. Summer Meeting

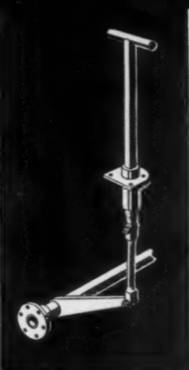
(*Continued from page 17*)

propriate speeches and the showing of a Naval film on lighter-than-air craft.

The high spot of the luncheon came when Mr. Burden presented Major Reuben Fleet with the Institute's Gold Key in recognition of his efforts in bringing the West Coast buildings into being. A second gold key—an actual passkey to the building entrance—was also presented to the Major by San Diego Section Chairman, Frank W. Fink.

The ceremonies ended in mid-afternoon with an inspection of the building and a feeling on the part of everyone that the Institute now has adequate facilities to better serve the industry and the aeronautical sciences in general on the West Coast.


S-700



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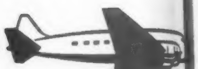
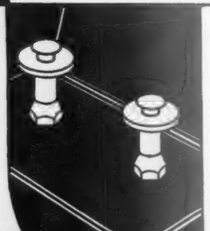
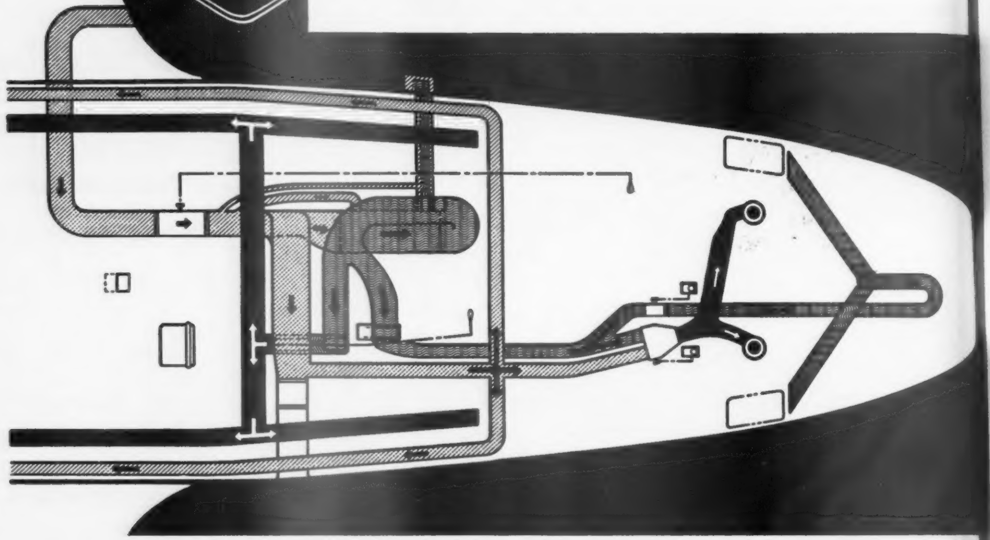




2 for the crew



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■ MIXED AIR

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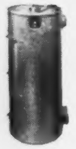
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V-15

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No.

171 Preliminary Development of a Jet-Propelled Helicopter—Roy E. Marquardt, President, Marquardt Aircraft Company.

172 The McDonnell Ram-Jet Helicopter—Charles R. Wood, Jr., Chief Helicopter Test Pilot and Manager, Helicopter Contracts, McDonnell Aircraft Corporation.

173 A Method for Improving the Inherent Stability and Control Characteristics of Helicopters—R. H. Miller, Associate Professor of Aeronautical Engineering, M.I.T.

174 Recent Developments in Rotary-Wing Aircraft—I. I. Sikorsky, Engineering Manager, Sikorsky Aircraft Division, United Aircraft Corporation.

175 The Pfund Sky Compass—Joseph B. Matthews, Jr., Head Navigation Branch, Airborne Equipment Division, Bureau of Aeronautics, Navy Department.

176 A Liquid Oxygen Converter for Aircraft—W. A. Wildhack, Chief, Missile Instrumentation Section, Electronics Division, and D. S. Goalwin, National Bureau of Standards.

178 The Sperry Zero Reader—S. Kellogg, Engineering Department Head for Flight Instruments, and C. F. Fragola, Engineering Section Head for Electronic Development, Sperry Gyroscope Company.

179 Convertible Aircraft—R. S. Barnaby, Chief, S. M. Berkowitz, Project Leader, and W. H. Colcord, Assistant Chief, Aeronautics Section, The Franklin Institute.

180 Present Status of Research on Boundary-Layer Control—A. E. von Doenhoff and L. K. Loftin, Full Scale Research Division, Langley Aeronautical Laboratory, N.A.C.A.

181 Measurements in Flight of Spanwise Wing Loading—W. Lavern Howland, Flight Service Engineering Supervisor, Lockheed Aircraft Corporation.

182 Some Problems Concerning the Three-Dimensional Flow in Axial Turbomachines—Frank E. Marble, Instructor in Aeronautics, Guggenheim Aeronautical Laboratory, California Institute of Technology.

183 Aerodynamic Hysteresis as a Factor in Critical Flutter Speed of Compressor Blades at Stalling Conditions—A. Mendelson, Lewis Flight Propulsion Laboratory, N.A.C.A.

184 Designing for Gas Turbine Materials—M. H. Young, Chief, Materials Laboratory, Wright Aeronautical Corporation.

187 Dynamic Stability at High Speeds from Unsteady Flow Theory—I. C. Statler, Aerodynamicist, Flight Research Department, Cornell Aeronautical Laboratory.

190 Two-Dimensional Jet Mixing of a Compressible Fluid—S. I. Pai, Cornell Aeronautical Laboratory.

192 Some Recent Measurements in a Two-Dimensional Turbulent Channel—John Laufer, California Institute of Technology.

197 A New Approach to the Design of Metering Pins in Oleo Struts—R. M. Rosenberg, Associate Professor of Aeronautical Engineering, University of Washington.

204 What the Air Lines Want in Navigation Aids—Ralph S. Damon, President, American Airlines, Inc. Now, President, T.W.A.

205 Military Air Transport Service Specifications and Requirements for Cargo Aircraft—Major R. R. Hajek, Chief of Aircraft Materiel and Equipment Branch, Division of Plans and Operations, M.A.T.S.

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240 The Operation of the VHF Omni-Range in the Transition System—Francis Moseley, Collins Radio Company.

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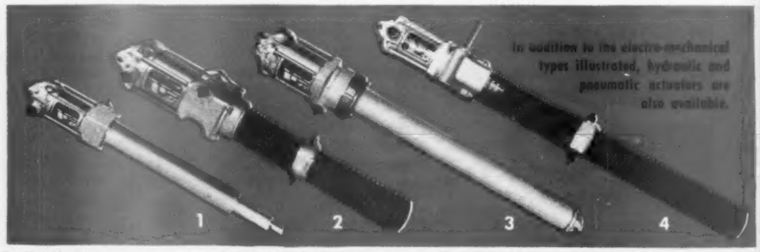

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Aerodynamics (2)

AERODYNAMIC LOADS

The Yawing Moment Due to Sideslip of Triangular, Trapezoidal, and Related Plan Forms in Supersonic Flow. Arthur L. Jones and Alberta Alksne. *U.S., N.A.C.A., Technical Note No. 1850,* April, 1949. 65 pp., figs. 10 references.

BOUNDARY LAYER

Integration of the Boundary-Layer Equations for a Plane in a Compressible Fluid. D. Meksyn. *Royal Society of London, Proceedings,* Series A., Vol. 195, No. 1041, December 7, 1948, pp. 180–188. 10 references.

Asymptotic integration of Emmons & Brainerd's nonlinear differential equations for the equations of motion of the boundary layer on a flat plate for arbitrary values of the Prandtl Number and the Mach Number. The method of asymptotic integration, which was developed to deal with the boundary layer in an incompressible fluid, gives ample accuracy in the first approximation. The results of this comparatively rapid calculation are in satisfactory agreement with those obtained by the lengthy calculation made by Emmons & Brainerd for specific values of Prandtl and Mach Numbers.

Effect on Aerofoil Drag of Boundary-Layer Suction Behind a Shock Wave. A. Fage and R. F. Sargent. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 1913,* October 26, 1943. 22 pp., diagrs., figs. 11 references. British Information Services, New York. $1.30.

At the Reynolds Numbers of flight with an efficient slot and suction system, the drag coefficient at the critical Mach Number of a wing without suction can be retained at higher Mach Number by boundary-layer suction. Suction has little effect on critical Mach Numbers, but the minimum drag with suction on the upper surface is 40 per cent lower than the airfoil drag without suction. The drag coefficients at the critical Mach Numbers that can exist without suction are obtained with suction at Mach Numbers 0.08 higher. The drag falls to its minimum value when about 0.6 of the mass of the air in the boundary layer is removed. In the present experiments, the power saved by the reduction of drag due to suction is about the same as the estimated power absorbed by the compressor.

Heat Transmission in the Boundary Layer. L. E. Kalikhman. (*Prikladnaia Matematika i Mekhanika, Vol. 10, pp. 449–474, 1946.*) *U.S., N.A.C.A., Technical Memorandum No. 1229,* April, 1949. 43 pp., figs. 9 references.

Investigates laminar and turbulent boundary layers in the flow of a gas over two-dimensional bodies and over bodies of revolution with heat transfer through their surfaces. Momentum and energy integral relations for the boundary layer are derived. Various boundary-layer parameters that may be determined approximately and for which methods are given are: heat-transfer coefficients, friction coefficients, boundary-layer thicknesses, and the velocity and temperature distributions through the boundary layer. Formulas for the profile drag are given for the cases where shock waves are absent.

Gasdynamic Theory of Heat. L. E. Kalikhman. (*Prikladnaia Matematika i Mekhanika, Vol. 10, 1946, pp. 449–474.*) *U.S., Air Force, Air Materiel Command, Technical Report No. F-TS-1211-1A (GDAM A9-T-30),* January, 1949. 51 pp., figs. 9 references. (See preceding abstract.)

Lecture Series "Boundary Layer Theory." I—Laminar Flows. II—Turbulent Flows. H. Schlichting. (*Luftfahrtforschungsanstalt Hermann Göring, Braunschweig, 1941–1942.*) *U.S., N.A.C.A., Technical Memorandums Nos. 1217, 1218,* April, 1949. 165, 136 pp.; diagrs., figs. 39, 115 references.

Exact Calculation of Laminar Boundary Layer in Longitudinal Flow Over a Flat Plate with Homogeneous Suction. Rudolf Iglisch. (*Schriften der Deutschen Akademie der Luftfahrtforschung, Vol. 8B, No. 1, 1944.*) *U.S., N.A.C.A., Technical Memorandum No. 1205,* April, 1949. 69 pp., figs. 17 references.

Research Narrows Boundary Control Use. Albert E. Von Doenhoff and Laurence K. Loftin, Jr. *Aviation Week,* Vol. 50, No. 16, April 18, 1949, pp. 25, 26, 28, fig. (Extended summary of a paper.)

CONTROL SURFACES

High-Lift and Lateral Control Characteristics of an NACA 65_2-215 Semispan Wing Equipped with Plug and Retractable Ailerons and a Full-Span Slotted Flap. Jack Fischel and Raymond D. Vogler. *U.S., N.A.C.A., Technical Note No. 1872*, April, 1949. 34 pp., diagrs., figs. 15 references.

Systematic Investigations of the Effects of Plan Form and Gap Between the Fixed Surface and Control Surface on Simple Flapped Wings. Gothert and Röber. (*ZWB Forschungsbericht Nr. 552/4, February 16, 1940.*) *U.S., N.A.C.A., Technical Memorandum No. 1206*, May, 1949. 39 pp., figs. 1 reference.

FLUID MECHANICS & AERODYNAMIC THEORY

One-Dimensional Flows of an Imperfect Diatomic Gas. A. J. Eggers, Jr. *U.S., N.A.C.A., Technical Note No. 1861*, April, 1949. 32 pp., figs. 21 references.

Expressions for analyzing one-dimensional flows of a diatomic gas and their application to flow through normal and oblique shocks in free air at sea level. Below Mach Number 10, the pressure ratio across a normal shock differs little from its ideal gas value. At Mach Numbers above 4, the temperature rise, however, is considerably below, and hence the density rise is well above that predictable for an ideal gas. The influence of gaseous imperfections on the lift and pressure drag of a flat plate operating at Mach Numbers of 10 and 20 is small.

The Application of Green's Theorem to the Solution of Boundary-Value Problems in Linearized Supersonic Wing Theory. Max A. Heaslet and Harvard Lomax. *U.S., N.A.C.A., Technical Note No. 1767*, April, 1949. 41 pp., illus., diagrs., figs. 23 references.

General methods of solution under the assumptions of linearized theory for two- and three-dimensional steady-state and two-dimensional unsteady-state equations of compressible flow. In all cases, solutions depend on the use of Green's equivalent layer of sources, sinks, and doublets. Emphasis is placed on applications in supersonic wing theory. The singularities arising in the integrations are treated by Hadamard's finite part technique. The growth of load distribution over a specific sweptback lifting surface is calculated at a free-stream Mach Number of 1.0.

Calculation of the Curvatures of Attached Shock Waves. T. Y. Thomas. *Journal of Mathematics and Physics*, Vol. 27, No. 4, January, 1949, pp. 279–297, figs.

Calculation of the ratio of the curvature of a shock line arising at the vertex of a pointed cylindrical obstacle in a plane uniform flow of constant pressure, density, and velocity vector, and the curvature of the streamline immediately behind the shock. The angle of inclination of the obstacle and the curvature of the streamline are specified by the boundary conditions. Tables and graphs of the ratios as functions of the angle of the shock line through 90 degrees are given for fixed, equally-spaced, Mach Number values from 1.05 to 4.45.

Note on Stability of Laminar Viscous Flow Between Parallel Planes. D. Meksyn. *Royal Society of London, Proceedings, Series A*, Vol. 195, No. 1041, December 7, 1948, pp. 174–179. 11 references.

The transformation through the critical points of the slowly varying integrals in the fourth-order differential equation for the stability of laminar flow in two dimensions, which was used by the author to obtain a rigorous solution of the equation, is presented in a form which permits his results to be compared with those obtained by Heisenberg and Tollmien. The terms that were neglected in Tollmien's treatment are shown to have no effect on his final result and the method to be valid in hydrodynamic problems.

Rotation in Free Fall of Rectangular Wings of Elongated Shape. Paul Dupleich. (*Publications Scientifiques et Techniques du Secrétariat d'Etat a l'Aviation, No. 176, 1941.*) *U.S., N.A.C.A., Technical Memorandum No. 1201*, April, 1949. 99 pp., illus., figs. 6 references.

Experimental investigation of the tumbling motion of the flat plate with variable aspect ratio, span chord, and loading in a free fall in air and water. The steady motion is sustained by aerodynamic moments and is defined for any given flat plate by empirical relationships that are functions of the design variables. Discussion includes the motion of paddle wheels, prisms, the circular cylinder, isosceles trapezoids, and graphite flakes.

The Application of the Hodograph Method to Problems of Subsonic Compressible Flow in Two Dimensions. J. W. Craggs. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2273*, July, 1946. 16 pp., figs. 10 references. British Information Services, New York. $1.00.

Derivation and reduction to the simplest form of the hodograph equations for two-dimensional irrotational compressible flow, and discussion of the problems in assigning boundary conditions and in transforming hodograph solutions into the flow plane. Approximate solutions of the flow equations, in which powers of the Mach Number greater than the second are neglected, and the Prandtl-Glauert solutions for linear perturbations are both included in the von Kármán-Tsien solutions, which use a linearized equation of state. A general method is given for the use of the linearized equation of state for flows around airfoils, with circulation present, and, as an illustrative example, the flow for a symmetrical Joukowsky airfoil is calculated for angles of incidence zero and 0.05 radian (2°52′) at a stream Mach Number of 0.6.

Use of Characteristic Surfaces for Unsymmetrical Supersonic Flow Problems. W. E. Moeckel. *U.S., N.A.C.A., Technical Note No. 1849*, March, 1949. 49 pp., diagrs., figs. 16 references.

The three-dimensional nonlinear partial differential equation for the velocity potential in a supersonic stream is transformed by the method of characteristics to a system of three difference equations for computing the supersonic potential flow past unsymmetrical boundaries. Application of the method of characteristics to the linearized three-dimensional equation results in a relatively simple system of difference equations that can be used to compute the supersonic flow past boundaries for which no other linearized solutions are available.

Gas Motion in a Local Supersonic Region and Conditions of Potential-Flow Breakdown. A. A. Nikolskii and G. I. Taganov. (*Prikladnaia Matematika i Mekhanika, Vol. 10, No. 4, 1946, pp. 481–502.*) *U.S., N.A.C.A., Technical Memorandum No. 1213*, May, 1949. 35 pp., figs. 6 references.

An investigation carried out directly in the flow plane of the flow in a local supersonic region that is bounded by the contour of a body and by the transition line between the supersonic and the surrounding subsonic flow. The inclination of the body contour, at any point, is the arithmetic mean of the inclination of the velocity vectors of the flow at those loci on the transition line which terminate at the characteristic arising from the point. If the line of transition is not a discontinuity, the angle of inclination of the velocity vector along it varies monotonically. Along any portion of the contour that is a straight line, the velocity of the flow decreases. For profiles convex to the flow, the breakdown of potential flow that occurs when the Mach Number of the oncoming flow increases cannot be attributed to the formation of an envelope of the characteristics within the supersonic region. The monotonic variation of the velocity vector at the transition line is used to find the transitional Mach Number beyond which the potential flow, with a local supersonic region, becomes impossible and at which a shock wave arises.

On Supersonic Flow Patterns. M. M. Munk. *Journal of Applied Physics*, Vol. 20, No. 4, April, 1949, pp. 302–305, figs. 5 references.

In steady plane two-dimensional potential flow of a perfect gas, the Mach lines have zero curvature at a special Mach Number that is a function of the expansion exponent of the flow. The relationship can be used to increase the accuracy and to simplify the construction of streamline and Mach line patterns.

Mean Value and Correlation Problems Connected With the Motion of Small Particles Suspended in a Turbulent Fluid. Tchen Chan-Mou. *Delft, Technische Hogeschool, Laboratorium voor Aero- en Hydrodynamica, Mededeeling No. 51*, 1947. 131 pp., figs. 21 references.

Derivation of a dispersion equation that governs the diffusion of irregularly moving particles suspended in a fluid in turbulent motion. The general theory of dispersion phenomena is considered to establish the quantities by which the diffusion is characterized, and, from values to be assigned to these quantities, are derived data characterizing the irregular motion of the liquid. Theorems on mean values and on correlation problems made possible the calculation of these values. The motion of the particles is a statistical problem in which it is impossible to consider every particle individually. Therefore, the common properties of a multitude of particles are obtained in part by considering the simultaneous behavior of the particles belonging to a certain group at a particular instant, and in part by following a single particle during an extended interval of time and calculating mean values over this interval. In the first part, dispersion functions refer to the displacements of particles or to their velocities at a given instant. This investigation is based principally on the method developed by Kolmogoroff. In the second part, the most important time mean values are those of the square of the velocity, the square of the length of the path, and the product of the length of the path, and the velocity at the endpoint.

The Role of Big Eddies in Homogeneous Turbulence. G. K. Batchelor. *Royal Society of London, Proceedings, Series A*, Vol. 195, No. 1043, February 3, 1949, pp. 513–532. 13 references.

Examination of the motion of the largest eddies in turbulence—i.e., those that contain very little energy during the initial period, that are not similar to the smaller eddies, and that produce a change in the law of decay at the end of the initial period. The spectrum tensor that is introduced, which is defined as the three-dimensional Fourier transform of the double-velocity correlation tensor, is unlike the conventional one-dimensional spectrum function in that it is suitable for the application of similarity hypotheses. The terms of the first and second degree in the expansion of the spectrum function are constant throughout the decay. The biggest eddies of the turbulence are therefore permanent. They are determined wholly by the initial conditions and are dominant in the final period when the smaller eddies have decayed. The action of the smaller eddies on the invariant big eddies is equivalent to that of a turbulent viscosity, the value of which may vary with direction.

L'analyse Spectrale de la Turbulence (The Spectral Analysis of Turbulence). R. Betchov. (*Delft, Technische Hogeschool, Laboratorium voor Aero- en Hydrodynamica, Mededeeling No. 58a.*) *Amsterdam, Koninklijke Nederlandsche Akademie van Wetenschappen, Verhandelingen*, Vol. 51, No. 9, pp. 1–10, diagrs., figs. 3 references. (In French.) (Reprint.)

Spectral Analysis of an Irregular Function. J. M. Burgers. (*Delft, Technische Hogeschool, Laboratorium voor Aero-en Hydrodynamica, Mededeeling No. 58b.*) *Amsterdam, Koninklijke Nederlandsche Akademie van Wetenschappen, Verhandelingen* Vol. 51, No. 10, pp. 11–24, figs. 6 references. (In English.) (Reprint.)

On the Theory of Statistical and Isotropic Turbulence. W. Heisenberg. *Royal Society of London, Proceedings, Series A*, Vol. 195, No. 1042, December 22, 1948, pp. 402–406. 12 references.

On Free Boundaries of an Ideal Fluid. II. Max Shiffman. *Communications on Pure and Applied Mathematics*, Vol. 11, No. 1, March, 1949, pp. 1–11, figs. 2 references.

Special examples, including unsymmetrical flows of the force on an obstacle caused by the formation of a cavity behind it. The principle of reflection across free boundaries is used to develop a geometrical interpretation from which the drag coefficient can easily be calculated.

Jet Diffusion in Proximity of a Wall (*ZWB Untersuchungen und Mitteilungen Nr. 3057*, December 21, 1943). *U.S., N.A.C.A., Technical Memorandum No. 1214*, May, 1949. 23 pp., figs. 3 references.

When auxiliary jet engines are installed on air frames, as well as in some new designs, the jet engines are mounted in such a way that the jet stream exhausts in close proximity to the fuselage. This report deals with the behavior of the jet in close proximity to a two-dimensional surface. The experiments were made to find out whether the axially symmetric stream tends to approach the flat surface. This report is the last of a series of four partial test reports of the Gottingen program for the installation of jet engines dated October 12, 1943, and it is the complement of the report on intake in close proximity to a wall.

Outflow of a Jet of Compressed Air into Moving Air. M. Schaefer. (*Dresden, Technische Hochschule, Peenemunde Archiv 44/13, 1944.*) *U.S., Air Force, Air Materiel Command, Technical Report No. F-TS-1204-1A* (*GDAM A9-T-15*), January, 1949. 16 pp., figs. 4 references.

Calculation of the flow of a jet with a velocity of Mach = 3.24 issuing from a truncated cone that comprises the stern of an A-4 rocket, in order to determine the proper configuration of the nozzle.

Atomization of Liquids by Centrifugal Nozzles. I. I. Novikov. (U.S.S.R., Journal of Technical Physics, Vol. 18, No. 3, 1948, pp. 345–354.) *The Engineers' Digest*, Vol. 10, No. 3, March, 1949, pp. 72–74, figs. 3 references.

Further Experiments on the Flow and Heat Transfer in a Heated Turbulent Air Jet. Stanley Corrsin and Mahinder S. Uberoi. *U.S., N.A.C.A., Technical Note No. 1865*, April, 1949. 61 pp., illus., diagrs., figs. 24 references.

Measurements of the mean total-head and temperature fields in a round turbulent jet with various initial temperatures show that the jet spreads more rapidly as its density becomes lower than that of the receiving medium, even when the difference is not sufficiently great to cause measurable deviations from the constant-density, dimensionless, dynamic-pressure profile function. Rough analytical considerations have given the same relative spread.

Some Dimensional Considerations in Fluid Mechanics. J. G. LaBerge. *Canada, National Research Council, Division of Mechanical Engineering, Aerodynamics Laboratory, Report No. MT-5*, May 20, 1948. 79 pp., figs. 80 references. A compilation and correlation of available information on dimensional analysis and physical similarity in the field of fluid mechanics.

PERFORMANCE

Effect of a 90° Cross Wind on the Take-Off Distance of a Light Airplane Equipped with a Cross-Wind Landing Gear. Seth B. Anderson, Burnett L. Gadeberg, and William H. McAvoy. *U.S., N.A.C.A., Technical Note No. 1898*, June, 1949. 11 pp., illus. 2 references.

STABILITY & CONTROL

Lateral Stability of Tailless Aircraft. A. W. Thorpe and M. F. Curtis. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2074*, June, 1943. 30 pp., figs. 8 references. British Information Services, New York. $1.75.

The probable effect on lateral behavior of a change from conventional aircraft to tailless designs. For the larger values of the coefficient of yawing due to yawing and the coefficient of sideforce due to sideslip, oscillatory instability is more likely to occur at low speed than at high, and instability at high speed is unlikely. For the smaller values of these coefficients, oscillatory instability is more likely at high speed than at low, and stability at high speed can be attained only with a small value of a negative coefficient of rolling moment due to sideslip. Spiral instability is probable at all speeds, but at high speed the rate of growth of this motion will be small. The survey stresses the need for systematic measurements of the coefficients of sideforce due to sideslip, yawing moment due to sideslip, and yawing moment due to yawing, for tailless configurations.

A Method of Calculating a Stability Boundary that Defines a Region of Satisfactory Period-Damping Relationship of the Oscillatory Mode of Motion. Leonard Sternfield and Ordway B. Gates, Jr. *U.S., N.A.C.A., Technical Note No. 1859*, April, 1949. 25 pp., figs. 6 references.

Spin-Tunnel Investigation to Determine the Effectiveness of a Rocket for Spin Recovery. Anshal I. Neihouse. *U.S., N.A.C.A., Technical Note No. 1866*, April, 1949. 19 pp., illus., diagrs. 7 references.

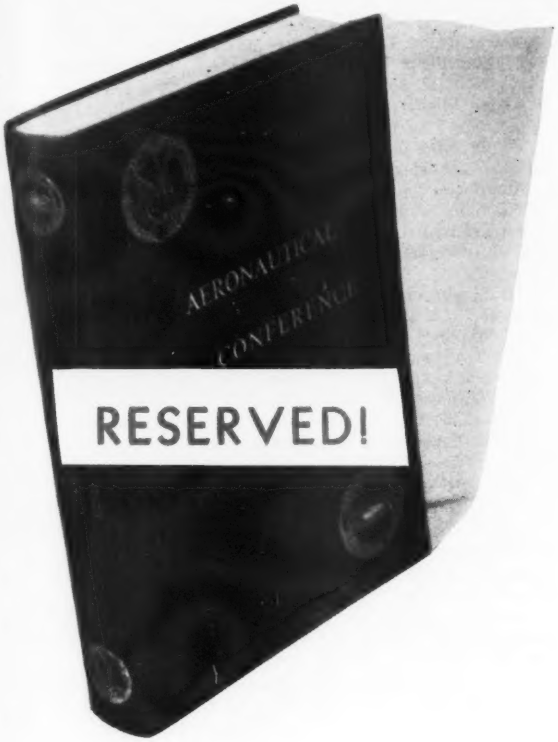
Correlation of Pilot Opinion of Stall Warning with Flight Measurements of Various Factors Which Produce the Warning. Seth B. Anderson. *U.S., N.A.C.A., Technical Note No. 1868*, April, 1949. 13 pp., figs. 3 references.

WINGS & AIRFOILS

A Simple Method of Estimating the Subsonic Lift and Damping in Roll of Sweptback Wings. Edward C. Polhamus. *U.S., N.A.C.A., Technical Note No. 1862*, April, 1949. 20 pp., figs. 17 references.

A method of modifying existing correction factors of lifting-surface theory to account approximately for the effects of sweep, and the application of these factors to existing lifting-line theories for the lift and damping in roll of swept wings. Comparison with experimental data in the low-speed and low lift range indicated good agreement for wings of any plan form. If the Glauert-Prandtl transformation is used, the formulas obtained can be applied to swept wings at subsonic speeds below the critical speed.

The Forces and Moments Over an NACA 0015 Airfoil Through 180° Angle of Attack. Alan Pope. *Aero Digest*, Vol. 58, No. 4, April, 1949, pp. 76, 78, 100, figs. 4 references (Extended summary of a report.)



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Theory of the Inversely Tapered Wing. Robert McLarren. *Aviation Week*, Vol. 50, No. 12, March 21, 1949, pp. 30–33, figs.

Effect of Compressibility on Lift and Load Characteristics of a Tapered Wing of NACA 64–210 Airfoil Sections up to a Mach Number of 0.60. F. E. West, Jr., and T. Himka. *U.S., N.A.C.A., Technical Note No. 1877*, May, 1949. 48 pp., illus., diagrs., figs. 15 references.

More Effective Than an Aileron. *The Martin Star*, March, 1949, pp. 4, 15, illus., diagr.

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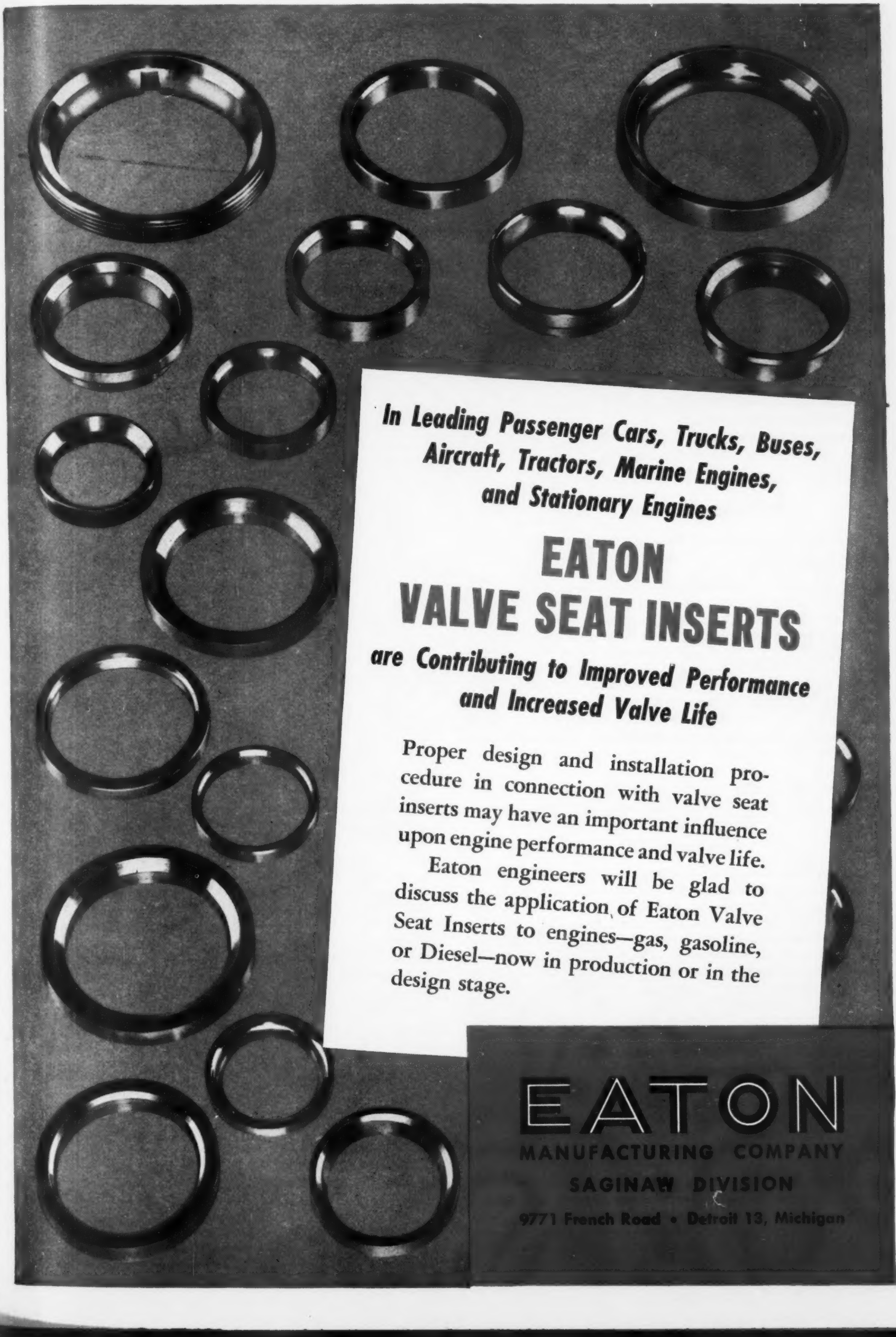

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The Pilot Speaks. G. S. Bakenstoe. *Journal of Aviation Medicine,* Vol. 20, No. 2, April, 1949, pp. 130–135, 140. Survey of opinions on medical requirements for pilot's license.

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Is the Passenger Worth Considering? An Analysis of the Meaning of Comfort in Traveling, with Conclusions upon its Eventual Effect upon Economics. M. N. Golovine. *Aeronautics,* Vol. 20, No. 5, April, 1949, pp. 38–41, diagr.

The Design of Aircraft Interiors. Walter Dorwin Teague. *Shell Aviation News,* No. 129, March, 1949, pp. 19–21.

Stratocruiser (Boeing) Interior. *Shell Aviation News,* No. 130, April, 1949, pp. 12, 13, illus.

Control Problems for Cabin Air. Frederick H. Green. *Aero Digest,* Vol. 58, No. 4, April, 1949, pp. 68, 70, 72, 74, 112–114, diagr., figs.

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The Curtiss-Wright Dehmel Electronic Flight Simulator Model 377. *Curtiss-Wright Corp., Propeller Division, Caldwell, N. J.* 10 pp., illus.

Duplicate control panel embodies actual parts of specific aircraft in order to simulate, for various situations, performance that would be obtained in a full-scale aircraft under actual conditions. The practice afforded under all normal and emergency condition reduces air-line flight training time and costs by one-third. Of the 600 panel items, 280 are relegated to the flight engineer. The simulator is also equipped to represent radio facilities.

Aviation Education; In the Schools. Stanley Brogden. *Aircraft,* Vol. 27, No. 5, February, 1949, pp. 15, 16, 42, illus.

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Electronics (3)

Theoretical Consideration of an Improved Glide Path Antenna System. Chester B. Watts. *U.S., Civil Aeronautics Administration, Technical Development Report No. 81,* March, 1949, 6 pp., figs.

A null-reference transmitting array for defining a glide path wherein the path angle is primarily determined by a null in the vertical radiation pattern of a single antenna located at a relatively great distance above the ground. A modifier antenna controls the path shape near the runway, and either straight line or curved path shapes near the bottom of the path may be produced. The path produced by this type of array should be considerably better than that of the present instrument landing system. It should afford greater paths stability after heavy snowfall, better linearity of indications with deviation from the path, and easier adjustment of the path shape near contact.

Radar- and Radio-Antenna for Air Force Aircraft. Fred H. Behrens. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest,* Vol. 14, No. 9, May 1, 1949, pp. 15–20, illus.

Descriptive discussion of the development of antenna-housings to encourage closer cooperation between aircraft design and plastics manufacture in the production of radomes. The housing for microwave radar frequency antennas requires accurately controlled gradation of wall thickness and material uniformity. Outer surfaces that can withstand rain and hail erosion need to be developed.

The Helical Antenna. John D. Kraus. *Institute of Radio Engineers, Proceedings,* Vol. 37, No. 3, March, 1949, pp. 263–272, diagrs., figs. 19 references.

Navion L-17A Radio Installation. C. L. Cahill. *Airports and Air Carriers,* Vol. 15, No. 3, March, 1949, pp. 32, 33, illus.

Plessey Develop Five-Channel Radio. *Airports & Air Transportation,* Vol. 4, No. 69, March, 1949, p. 31, illus.

All in One Package (Mitchell VHF Avigator). *Southern Flight,* Vol. 31, No. 3, March, 1949, pp. 15, 22, illus.

Subminiatures Call for New Skills. *Aviation Week,* Vol. 50, No. 15, April 11, 1949, pp. 18, 20–22, illus.

Subminiaturization of Intermediate Frequency Amplifiers. *U.S., National Bureau of Standards, Technical News Bulletin,* Vol. 33, No. 4, April, 1949, pp. 46–48, illus.

Ratio of Frequency Swing to Phase Swing in Phase- and Frequency-Modulation Systems Transmitting Speech. D. K. Gannett and W. R. Young. *Institute of Radio Engineers, Proceedings,* Vol. 37, No. 3, March, 1949, pp. 258–263, diagrs., figs. 1 reference.

The Application of Ionospheric Data to Radio Communication. Edward Appleton and W. J. G. Beynon. *Gt. Brit., Department of Scientific and Industrial Research, Radio Research, Special Report No. 18,* 1948. 44 pp., figs. 21 references. British Information Services, New York. $0.35.

Oversea Propagation on Wavelengths of 3 and 9 Centimeters. J. S. McPetrie, B. Starnecki, H. Jarkowski, and L. Sicinski. *Institute of Radio Engineers, Proceedings,* Vol. 37, No. 3, March, 1949, pp. 243–257, illus., figs. 10 references. Meteorological factors that control the propagation of centimeter waves.

Detection of Radio Signals Reflected from the Moon. John H. Dewitt, Jr., and E. K. Stodola. *Institute of Radio Engineers, Proceedings,* Vol. 37, No. 3, March, 1949, pp. 229–242, illus., diagrs., figs. 6 references.

Engineering Practices (49)

A Discussion on Computing Machines. *Royal Society of London, Proceedings, Series A,* Vol. 195, No. 1042, December 22, 1948, pp. 265–287, illus., diagrs., figs. 2 references.

Contents: *A Historical Survey of Digital Computing Machines,* D. R. Hartree. *General Principles of the Design of All-Purpose Computing Machines,* M. H. A. Newman. *The Design of a Practical High-Speed Computing Machine,* the EDSAC, M. V. Wilkes. *A Cathode-Ray Tube Digit Store,* F. C. Williams. *The Automatic Computing Engine at the National Physical Laboratory,* J. H. Wilkinson. *Recent Computer Projects,* A. D. Booth.

An Electrical Potential Analyser. S. C. Redshaw. *Institution of Mechanical Engineers, Proceedings,* Vol. 159, War Emergency Issue No. 38, 1948, pp. 55–62, Discussion, pp. 62–80, illus., diagrs., figs. 4 references.

An experimental alternative for Southwell's relaxation technique. By adjustment of values of circuit components the electrical analog can solve Poisson's and Laplace's equations and finite-difference problems involving irregular boundary conditions.

The Mechanical Differential Analyser; Its Principles, Development, and Applications. H. E. Rose. *Institution of Mechanical Engineers, Proceedings,* Vol. 159, War Emergency Issue No. 38, 1948, pp. 46–54, illus., diagrs. 16 references.

Equipment

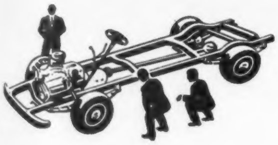
Accessories. *Aeronautics, Special Trilingual Edition,* 1949, pp. 114, 116, 117, 119, 120, 123, 125, diagrs. (In English, French, and Spanish.) Descriptions and drawings of 16 British-made aircraft accessories.

ELECTRICAL (16)

Case for High-Frequency Ignition System; Low-Tension Installation Intended to Offer Relief from High-Tension Ills. C. J. Watters. *Aviation Week,* Vol. 50, No. 17, April 25, 1949, pp. 20–24, illus.

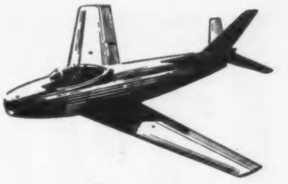
Carbon Pile Voltage Regulators for Aircraft. W. B. Kouwenhoven and G. J. Thaler. *Electrical Engineering,* Vol. 68, No. 5, May, 1949, p. 394, diagrs., fig.

The testing device of a *thousand uses*



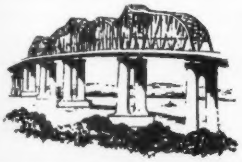
PRODUCT IMPROVEMENT

The Automotive Industry uses the SR-4 to check stresses and strains in vital parts, eliminate weaknesses, improve the product.



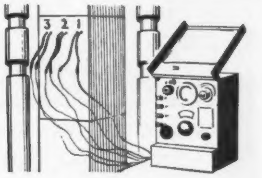
AIRCRAFT LIGHTENING

The Aircraft Industry uses the SR-4 to plot the complex flow of stresses in aircraft wings during flight, "balance" the design.



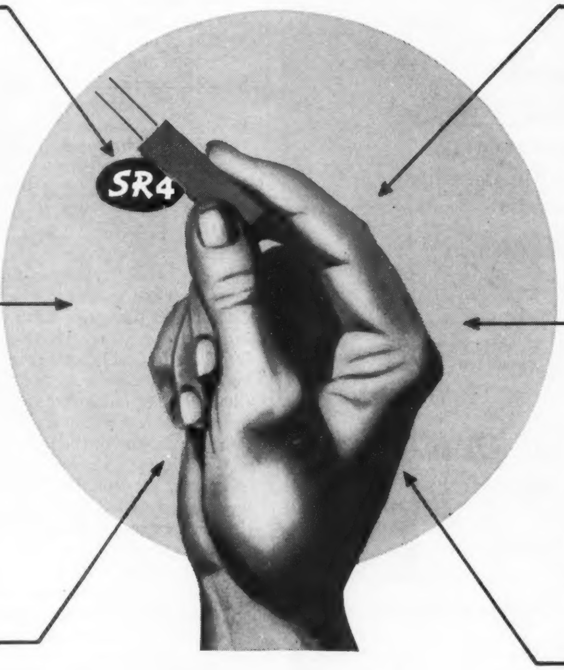
STRUCTURAL STRESS ANALYSIS

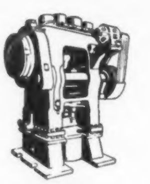
Engineering organizations check theoretical stress distribution against actual patterns, to verify design practice.



MASONRY STRESS DETERMINATION

The heavy construction industry is learning valuable new facts on how masonry withstands loading . . . with the SR-4.





MACHINE REDESIGN

Equipment manufacturers use the SR-4 to isolate the cause of puzzling breakages and to point the way to a correct solution.

MAKING BALLISTICS STUDIES

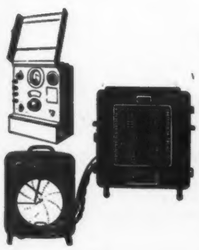
The flow of stress in a gun barrel as the bullet passed through was once a matter of theory... but a matter of accurate knowledge now, because of the SR-4.

BALDWIN SR4* STRAIN GAGE

It's hard to believe—yet this one little testing device, no larger than a postage stamp, has done more to broaden engineering knowledge through product analysis than all other testing equipment combined:

It has provided—for the first time—an accurate picture of actual stress distribution in such structural, equipment and machine parts as an airplane wing in flight . . . the interior of a mammoth masonry dam . . . the barrel of a cannon when the shell flashes from breech to muzzle . . . the frame of a punch press . . . the connecting rods of diesel engines during operation. In every instance, the new knowledge it revealed has permitted engineers to better the design job.

The long list of successful uses does not define the ultimate applications of the Baldwin SR-4 strain gage, but merely indicates its almost limitless possibilities. If you have any problem where unexplainable failures of parts are puzzling you . . . where some equipment must be lightened while retaining balanced strength . . . where a complete report of actual stress distribution in a structure will aid you in design . . . the Baldwin SR-4 can undoubtedly help you, as it has helped many others.



A comprehensive line of indicating, recording and switching instruments and equipment is available for both laboratory and field studies. The units illustrated include an SR-4 Strain Recorder Chart, and SR-4 Portable Strain Indicator, and an SR-4 Switching Unit, with which 48 strain gages can be switched in and out of service in as little as 50 seconds. These are only a few of many.

ASK FOR LITERATURE. Informative Technical Bulletins give a concise technical description of the SR-4 and collateral equipment. Ask for copies, indicating the type of testing in which you are interested.

The Baldwin Locomotive Works, Philadelphia 42, Pa., U. S. A. Offices: Boston, Chicago, Cleveland, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Seattle, St. Louis, Washington. In Canada: Peacock Brothers, Ltd., Montreal, Quebec.

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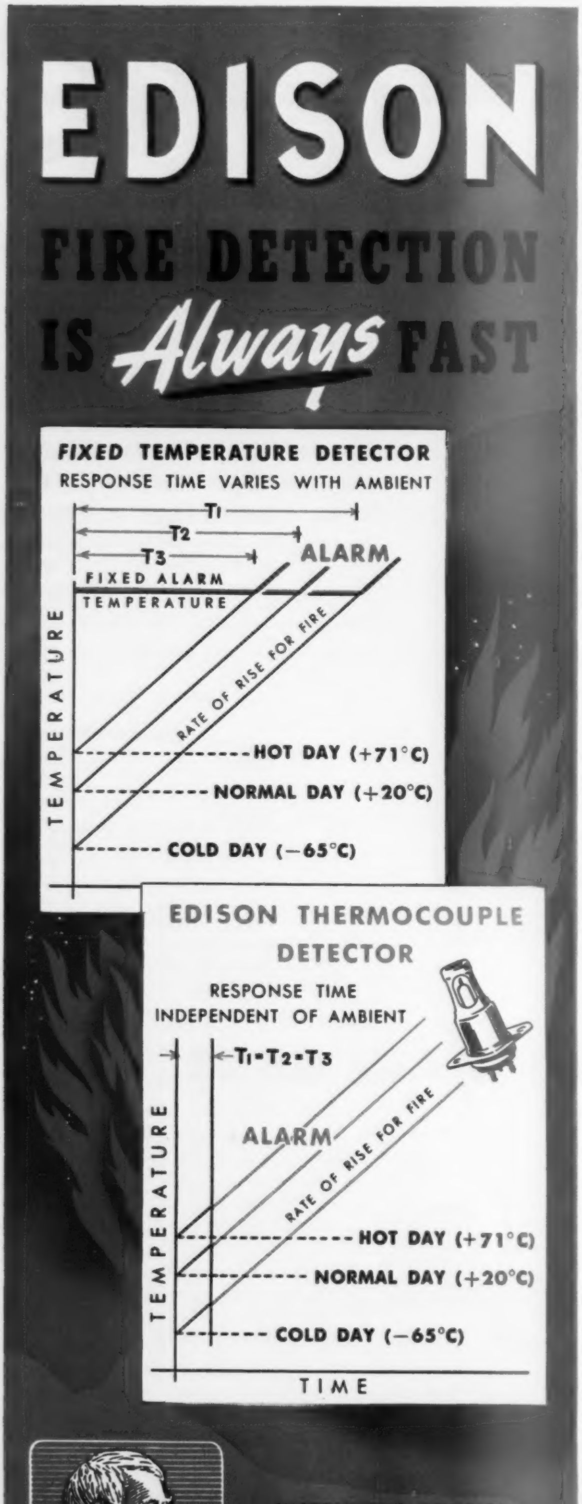
TESTING HEADQUARTERS BALDWIN



German Electronics in World War II. A. H. Sullivan, Jr. *Electrical Engineering,* Vol. 68, No. 5, May, 1949, pp. 403–409, illus., diagrs.

HYDRAULIC & PNEUMATIC (20)

Hydraulic Equipment. I—Manufacture of Undercarriage Components at Electro-Hydraulics, Ltd., Machining Methods, Deep Bores, Superfinishing. *Aircraft Production,* Vol. 11, No. 125, March, 1949, pp. 97–102, illus., figs.

Hydraulic Equipment. II—Manufacture of Components at Electro-Hydraulics, Ltd., Machining Thin-Walled Work, Furnace Brazing, Fixtures. *Aircraft Production,* Vol. 11, No. 126, April, 1949, pp. 136–140, illus., diagrs.

The Flow of Fluids Through Pipes & Orifices. *British Messier, Ltd., Technical Publication Dept., Brochure BM 119/200,* 1948. 16 pp., figs.

Permits the calculation, with reasonable accuracy, of the permissible restriction that may be introduced in a hydraulic system by its components. The provision of curves and nomograms, in addition to the usual formula, enables the calculation of the pressure drop thus introduced across an orifice and the pressure loss along the pipe.

Development and Testing of Fire-Resistant Hydraulic Fluids. D. H. Moreton. *S.A.E. Annual Meeting, Detroit,* January 10–14, 1949, Preprint. 15 pp., illus., diagrs., figs.

The research program that eventually selected the fire-resistant ester-base hydraulic fluid, DMX-8. Standard laboratory tests included viscosity, cloud and pour point, acidity, effect on elastomeric packings, flash and fire point, and autogenous ignition temperature. High-pressure arc, low-pressure spray, and full-scale hydraulic power system pump flammability tests were made. Tests covered five basic types of fluid: petroleum-base, silicone-base, halogenated-hydrocarbons water-base, and ester-base. DMX-8 meets or exceeds AMS 3150 nonflammability requirements, and in the hot manifold test exceeds the performance of the reference liquid. It consists almost entirely of high boiling point, low-volatility esters with fire resistance that will not be changed by aging, filtering, or selective evaporation of any of the components. Tests of packing and sealing materials emphasized the importance of considering the effects of proposed fluids on not only hydraulic packings, but on all types of materials used in aircraft and accessories.

A Completely Nonflammable Aircraft Hydraulic Fluid. B. B. Farrington, N. W. Furby, and J. M. Stokely. *S.A.E. Annual Meeting, Detroit,* January 10–14, 1949, Preprint. 8 pp., illus.

A halogenated hydraulic fluid, the principal ingredient of which is a halogenated nonaromatic hydrocarbon, is completely nonflammable, and noncorrosive to aircraft metals. It contains other additive materials to depress the freezing point, reduce wear, increase the viscosity index, and decrease foaming. It requires special rubber packings in place of AN-P-79 packings because of their excessive swelling, which heretofore rendered halogenated fluids unsatisfactory.

Special Products for Aircraft. Maxwell Smith. *Shell Aviation News,* No. 130, April, 1949, pp. 14–21, illus., diagrs., figs.

Evaluation of Non-Flammable Hydraulic Fluids. Fred O. Hosterman. *S.A.E. Annual Meeting, Detroit,* January 10–14, 1949, Preprint. 7 pp., figs.

Selection of an interim fluid is based on properties required by Aeronautical Material Specification 3150. Properties of typical nonflammable fluids of the water-base, ester-base, halogenated-"snuffer," and completely-halogenated types are compared with AN-O-466 for their effect on standard packings, absolute viscosity, toxicity, corrosion of metals, pump life, approximate weight in lbs. per gallon, and approximate cost per gallon. No interim fluid which meets all requirements of AMS 3150 has yet been developed.

Flight Operating Problems (31)

CLIMATIZATION

Some Aspects of Polar Flying. William H. Kearns, Jr. *U.S. Naval Institute, Proceedings,* Vol. 75, No. 5, May, 1949, pp. 550–559, illus.

HIGH ALTITUDE FLIGHT

High Altitude Flying. D. W. Richardson. *The Technical Instructor,* Vol. 4, No. 2, February, 1949, pp. 3–12. Military and commercial advantages of high-level flight, and a brief survey of power units and equipment for cabin air control, and ice prevention.

NACA Lowers High-Speed Flight Hurdles; Agency's Annual Report. *Aviation Week*, Vol. 50, No. 19, May 9, 1949, pp. 21, 22, 24–26, 29, 30, illus. 18 references.

If Hypoxia Sets In, There's Trouble; New Device Promises to Minimize Danger by Warning Flyers Before Lack of Oxygen Destroys Them. W. Lee Geist. *U.S. Air Services*, Vol. 34, No. 5, May, 1949, p. 18, illus.

ICE PREVENTION & REMOVAL

The Eternal Problem of Ice Forming. I—Anti-Icing Is Simple. Simon Haskin. **II—Thermo-Electric Effect for De-Icing.** Curtiss D. Bassett. *Aero Digest*, Vol. 58, No. 5, May, 1949, pp. 58–60, 100, figs. 5 references.

NOISE REDUCTION

Dynamometer-Stand Investigation of a Group of Mufflers. Don D. Davis, Jr., and K. R. Czarnecki. *U.S., N.A.C.A., Technical Note No. 1838*, March, 1949. 48 pp., illus., diagrs., figs. 3 references.

Engine and propeller noise are about equal and both must be reduced to accomplish a sizable reduction in overall noise. The loudest single component of engine-exhaust noise is the fundamental firing frequency of the engine. The cross-sectional shape of the muffler has no measurable effect on the muffler characteristics if the cross-sectional area and all other measurements are constant.

Measurement of Sound Levels Associated with Aircraft, Highway and Railroad Traffic. R. L. Field, T. M. Edwards, Pell Kangas, and G. L. Pigman. *U.S., Civil Aeronautics Administration, Technical Development Report No. 68*, July, 1947. 61 pp., illus., diagrs., figs.

PILOTING TECHNIQUE

Turning Flight. Daniel O. Dommasch. *Aero Digest*, Vol. 58, No. 5, May, 1949, pp. 54–56, 105, 106, figs.

REFUELING IN FLIGHT

Flight Re-Fuelling. H. R. Bunn. *Aeronautics, Special Trilingual Edition*, 1949, pp. 82, 84, 87, 88, 91, figs. (In English, French, and Spanish.)

Fueling aircraft after take-off permits a lighter take-off load, improved climb performance on three engines, and a less difficult immediate emergency landing. Refueling in flight is preferable to take-off assists for shortening runways needed in an emergency and to the powered "flying undercarriage," whose required size limits commercial application.

Adding Fuel in Flight. C. H. Latimer-Needham. *SAE Journal*, Vol. 57, No. 5, May, 1949, pp. 34–37, diagrs., figs. (Extended summary of a paper: Refuelling in Flight.)

Boeing B-50 Circles World Nonstop in 94 Hours; Air Force Plane Refuels Four Times in Air. *U.S. Air Services*, Vol. 34, No. 3, March, 1949, p. 21.

Globe Hop Sets (Boeing) B-50's New Role; Nonstop Flight Confirms Claims that Refueling Puts All Medium Bombers in the Intercontinental Classification. *Aviation Week*, Vol. 50, No. 11, March 14, 1949, pp. 14, 15, illus.

WEATHER HAZARDS

All-Weather Patrol. Cy Caldwell. *Aero Digest*, Vol. 58, No. 4, April, 1949, pp. 38, 39, 108–112, illus.

Flight Safety & Rescue (15)

Research for Aircraft Safety. C. C. Furnas. *Aeronautical Engineering Review*, Vol. 8, No. 7, July, 1949, pp. 18–21, 29, illus. 12 references.

Although improvement of the structural and operational integrity of aircraft in the air requires, for the most part, only development, research is still needed in nonflammable fuels and lubricants, icing protection, high-speed dynamic control, and the dynamics of stall. The prevention of aircraft collisions and crash landing depends on the development of electronic devices and the establishment of a traffic control system that will eliminate the difficulties presented by adverse weather conditions. Crash alleviation research has shown the importance of preventing crash fires and the feasibility of designing aircraft interiors to minimize impact injury.

Traffic Control Research. G. E. Bell. *Flight*, Vol. 55, No. 2098, March 10, 1949, p. 292. (Summary of a paper.)

Pointing The Way To Safety; Accident Investigation in Relation to Aircraft Design. Vernon Brown. *Flight*, Vol. 55, No. 2103, April 14, 1949, pp. 436, 437. (Extended summary of a paper.)

60 Points to Safety. Ernest W. Fair. *Aviation Operations*, Vol. 11, No. 4, March, 1949, pp. 31, 58, 61. Sources of accidents compiled from 1948 records and recommendations for their prevention.

Analysis of Crashes in Military Aircraft. N. M. Thorne. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 8, April 15, 1949, pp. 5–8.

Assessment of the responsibility for air safety and suggested remedies for human error which causes approximately 65 per cent of all aircraft accidents. Reduction of human error as pilot proficiency increases, the elimination of misinformation, mandatory checks and maintenance, and preparation for the uncontrollable are prerequisites of safe flying.

The Pilot's Viewpoint. J. W. G. James. *Flight*, Vol. 55, No. 2098, March 10, 1949, pp. 289, 290. (Summary of a paper.)

Physiological Aspects. K. G. Bergin. *Flight*, Vol. 55, No. 2098, March 10, 1949, pp. 290–292. (Summary of a paper: The Physiological Aspects of Air Safety.)

Airworthiness and Safety. J. D. North. *Flight*, Vol. 55, No. 2098, March 10, 1949, pp. 288, 298. (Summary of a paper: *Some Aspects of the Relationship Between Airworthiness and Safety.*)

Safety Improved Electric Connectors for Firewalls. Don A. Davis and Leslie Baird. *Aero Digest*, Vol. 58, No. 4, April, 1949, pp. 62, 63, 117, illus.

Research in Aircraft Fire Protection. D. G. Faust. *Aero Digest*, Vol. 58, No. 5, May, 1949, pp. 62, 63, illus.

New Fire-Killer Evaluated in Tests. *Aviation Week*, Vol. 50, No. 11, March 14, 1949, pp. 28, 31. C-B, monochloro-monobromomethane, has fire-extinguishing power equal to that of methyl bromide without its toxic or corrosive effect. Between 11 and 12 per cent more C-B can be stored in a container of given volume.

U. S. Air Force Studies on Fire Prevention Measures for Rocket Propelled Aircraft. *National Fire Protection Association, Committee on Aviation and Airport Fire Protection, Bulletin No. 34*, April, 1949. 2 pp.

Design Crash Protection Into Lightplanes; Study of "Survivable" Mishaps Gives Basic Knowledge Which has been Used to Make Occupants Safer. *Aviation Week*, Vol. 50, No. 18, May 2, 1949, pp. 19–22, illus.

Air-Sea Rescue Bomb (SOFAR). *Aviation Week*, Vol. 50, No. 18, May 2, 1949, p. 32, illus.

Emergency Exit. *Aeronautics, Special Trilingual Edition*, 1949, pp. 94, 95, 97, 98, figs. (In English, French, and Spanish.) The operating mechanism of the Martin-Baker ejection seat, predicted performance, and a summary history of aircraft escape techniques.

Standard Nomenclature for Airspeeds with Tables and Charts for Use in Calculation of Airspeed. William S. Aiken, Jr. *U.S., N.A.C.A., Report No. 837*, 1946. 19 pp., figs. 7 references. U.S. Govt. Printing Office, Washington. $0.20.

Symbols and definitions of air-speed terms now standardized by N.A.C.A. Equations, charts, and tables enable the determination of true air-speed, impact, and dynamic pressure, and Mach and Reynolds numbers. The report gives basic equations and constants on which are based charts of standard atmosphere to 65,000 ft. and the tentative values for altitudes up to 100,000 ft.

Flight Testing (13)

Test Instrumentation. *Flight*, Vol. 55, No. 2102, April 7, 1949, pp. 404–406, figs.

Streamlined Aircraft Weighing. Albert I. Dunstan. *Aero Digest*, Vol. 58, No. 4, April, 1949, p. 30, figs.

Fuels & Lubricants (12)

Engine Knock and Molecular Structure of Hydrocarbons. Wheeler G. Lovell. *SAE Quarterly Transactions*, Vol. 2, No. 4, October, 1949, pp. 532–538, figs.

Empirical examination of the combustive behavior of paraffin, cyclopentane, cyclohexane, aromatic, and straight-chain olefin hydrocarbons with respect to knock and the relationship between knock and molecular structure. Knocking characteristics of the paraffin hydrocarbons are shown in plots of the critical compression ratio at which knock begins, against the number of carbon atoms in the molecule. The number of carbon atoms is indicated by a simplified structural formula. Important in an examination of the relative quality of pure hydrocarbons is the engine in which they are used and the fuels' sensitivity to engine change. From data where the critical compression ratio under one set of conditions is plotted against the critical compression ratio in the same engine under another set of conditions, the paraffins show regular class behavior in being the least sensitive. The sensitivity of other classes to engine change is greater, and it can be correlated with their molecular structure. The addition of tetraethyl lead to paraffin hydrocarbons increases the antiknock level, but its effect upon other fuels is extremely variable.

Full-Scale Engine Performance Characteristics of Aviation Safety-Type Fuels. W. J. Sweeney, J. F. Kunc, Jr., W. C. Howell, Jr., and O. G. Lewis. *SAE Quarterly Transactions*, Vol. 2, No. 4, October, 1949, pp. 613–626, figs. 5 references.

Comparison of low volatility gasolines with those of conventional volatility by tests in a Wright Cyclone R-1820-56 engine, modified for direct cylinder fuel injection. Knock-limited performance of combinations of two isoparaffin components and two aromatic concentrates over the useful fuel-air range was obtained by a modified supercharged CFR engine procedure known as the AFD-F-13 method, which gave an indication better than that obtained with the F-3 and F-4 rich methods. Using the highest antiknock quality aromatic concentrate reduces the antiknock requirement of the base stock required for a given grade of low-volatility fuel. These fuels all exhibited essentially the same brake specific fuel consumption as fuels of conventional volatility, and they are more economical because of their greater volumetric heat content. Oil dilution is not a problem unless unusually low engine operating temperatures are encountered. Starting characteristics, with a warm engine in the normal operating range, are entirely satisfactory. Despite considerable exhaust smoke, maintenance checks showed the engine to be cleaner than it would have been if operated on conventional-volatility fuels.

Aeration of Aircraft Lubricating Oils Over a Range of Temperature. W. W. Woods and J. V. Robinson. *U.S., N.A.C.A., Technical Note No. 1846*, April, 1949. 27 pp., illus., diagrs. 1 reference.

Visual demonstration and measurement of the amount of air in aeronautical lubricating oil at 100° C. Three mechanical methods were used to produce the emulsions: an electric mixer; the colloid mill; and the gear-pump circulating system. The greatest air content of any emulsion was about 15 per cent by volume with oil containing lubricating additives. Unmodified oil formed emulsions containing 12 per cent air. The emulsified aeration was reduced to a minimum of 2 to 4 per cent by the use of either Dow Corning Fluid Type 200 or a mixture of glycerol with Aerosol OT. These two mixtures completely eliminated surface froth.

Review of Emulsified Antifoams for Aircraft Lubricating Oils. W. W. Woods and J. V. Robinson. *U.S., N.A.C.A., Technical Note No. 1847*, March, 1949. 31 pp., tables. 10 references.

Defoaming by insoluble antifoams. Four types exist: an oil-insoluble agent of lower surface tension that forms stable emulsions with the oil; an oil-insoluble agent of lower surface tension whose emulsions are stabilized by a second agent; an oil-insoluble agent whose surface tension is reduced and emulsions stabilized by a second agent; and an oil-insoluble agent whose surface tension is reduced by a second agent and whose emulsions are stabilized by a third. The defoaming ability of antifoams is predicted from their ability to form stable emulsions and from surface tension measurements, lower than those of the oils.

Analysis of Properties of Foam. J. W. McBain, Sydney Ross, and A. P. Brady. *U.S., N.A.C.A., Technical Note No. 1840*, March, 1949. 25 pp., figs. 18 references.

An investigation of the relation between the ease of formation of foam, its stability, and the amount of foam formed shows stability to be an intrinsic property of the liquid system and the amount of foam to depend not on its stability but on the mechanism of its production.

Quantitative Study of Variations in Concentration of Glycerol and Aerosol OT on Foaming Volume of Oil at Room Temperature. J. W. McBain and Sydney Ross. *U.S., N.A.C.A., Technical Note No. 1841*, April, 1949. 10 pp., tables. 3 references.

In comparison with the effects of other mixtures present in comparable amounts, both Gulf Agent and Aerosol-OT-glycerol mixtures prohibited the formation of the normal volume of foam to the same extent and in the optimum cases reduced the foam to one-tenth of its normal volume.

Effect of Various Compounds in Use with Airplane Engines upon Foaming of Aircraft Lubricating Oil. J. W. McBain and W. W. Woods, *U.S., N.A.C.A., Technical Note No. 1843*, April, 1949. 18 pp., figs. 1 reference.

Of over 60 compounds used that may contaminate aircraft lubricating oil, only 13 have a more than negligible effect upon the foaming of lubricating oil. Of these some were strong foaming agents.

The Effect of Aeration of the Oil on the Behaviour of an Engine Lubricating System Under High Altitude Conditions. E. Giffen and R. Mills. *Royal Aeronautical Society, Journal*, Vol. 53, No. 460, April, 1949, pp. 383–404, diagrs., figs. 11 references.

The effect of aeration on pump performance and on frothing depends on the amounts of free air and dissolved air in the oil and on the conditions tending to cause air to go into or come out of solution at different parts of the lubrication circuit. The measurement of the effect requires separate determination of free and dissolved air. Important factors that determine the degree of saturation of air in oil are the rates at which pressure changes occur, the amount of churning to which the oil is subjected, and the time available for the release of absorbed air. Of expedients tested to improve pump delivery and to reduce frothing, bypassing the "hot pot" in the oil tank was the most effective. Oil in the pump section was almost free of air, and the pump delivery was almost independent of altitude pressure over the range tested. Other expedients included a deaerator in the scavenge line, a pressurizing valve in the vent pipe, an injector in the pressure pump suction line, and an antifrothing dope.

Surface Properties of Oils. J. W. McBain and James V. Robinson. *U.S., N.A.C.A., Technical Note No. 1844*, March, 1949. 17 pp., tables. 16 references.

Film viscosities and surface tensions are determined from the behavior of single bubbles on the surface and from the coalescence of pairs of bubbles below the surface for several pure and binary liquids. Excessive viscosity is not responsible for surface oil stability except in modified oils where adsorption at the air interface causes formation of solid films responsible for stabilizing the foams. Foam inhibitors, however, increase, leave unchanged, or slightly decrease the film viscosity. Investigation to determine whether mixtures of hydrocarbons could form stable films, or whether a surface-active "foaming agent" must be present, showed, from the time of coalescence of pairs of bubbles held below the surface, that while pure liquids cannot form stable films some of the binary mixtures thereof form films of finite, although limited, stability. The inference is not excluded that the observed foaming ability of unmodified lubricating oils may be due partly to the mixture of hydrocarbons. Additives, foam stabilizers, and foam inhibitors do not act by their effect upon surface tension. Although foaming was greatly changed, surface tension was not affected except in the single case where Gulf Agent greatly lowered the surface tension of Aeroshell 120.

Effect of Fuel Properties on the Performance of the Turbine Engine Combustor. Louis C. Gibbons and Edmund R. Jonash. *Air World*, Vol. 1, No. 6, April, 1949, pp. 126–133, illus., diagrs., figs. 2 references.

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Winch Launching. Peter Fletcher. *Sailplane and Glider*, Vol. 17, No. 4, April, 1949, p. 80.

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A detailed survey of difficulties encountered in the control of military and research missiles. Representative performance numbers illustrate the engineering difficulties associated with the design and manufacture of control system components. New designs use hydraulic equipment in the missile to deliver fuel, operate control surfaces, and to facilitate handling and launching on the ground. These include pump accumulator control valve with electric input, servo with electric displacement follow-up, angular displacement and rate detectors, and electronic amplifiers. Requirements of compactness, efficiency, and low cost are engendered because of the expendable nature of the missile.

Ballistic Rockets. William Bollay. *North American Skyline*, Vol. 7, No. 1, May, 1949, pp. 12–15, illus., diagrs.

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The Atomic Rocket. IV. L. R. Shepherd and A. V. Cleaver. *British Interplanetary Society, Journal*, Vol. 8, No. 2, March, 1949, pp. 59–70. 1 reference.

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AUTOMATIC CONTROL

Basic Principles of Automatic Control Systems. A. Porter. *Institution of Mechanical Engineers, Proceedings*, Vol. 159, War Emergency No. 38, 1948, pp. 25–34, Discussion, pp. 34–45, diagrs., figs. 9 references.

Performance of automatic control systems is assessed by the speed of response of the system to a sudden disturbance, the nature of the response, and the magnitude of the steady-state errors. System stability and the elimination of steady-state errors can be achieved by incorporating subsidiary feed-back loops that short circuit time lags. For illustration the responses of idealized automatic thermal regulating systems, some of which incorporate "disturbance feed-back," are compared with others containing straight-forward controllers.

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Boeing Service Guide, No. 19, April, 1949. Contents: Stratocruiser Exterior Doors. Maintenance of Acrylic Plastic Windows.

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Materials (8)

METALS & ALLOYS

Tension Properties of Aluminum Alloys in the Presence of Stress-Raisers. II—Comparison of Notch Strength Properties of 24S-T, 75S-T, and 24S-T86 Aluminum Alloys. E. L. Aul, A. W. Dana, and G. Sachs. *U.S., N.A.C.A., Technical Note No. 1831*, March, 1949. 62 pp., diagrs., figs. 142 references.

Stresses and ductilities of mildly notched bars with circumferential V-shaped notches derived from test results for a considerable range of triaxialities. Fracture stress of the alloys increased, whereas the ductility simultaneously decreased with increasing triaxiality. Over the entire range of triaxiality and in regular tension tests, the actual fracture stress of 75S-T was considerably higher than that of 24S-T86, and that of 24S-T was intermediate. Ductility of 75S-T under conditions present in regular tension tests was higher than that of 24S-T, but decreased more rapidly with increasing triaxiality than 24S-T to smaller values at the highest triaxialities obtainable in the notched specimens. The 24S-T86 alloy possessed ductilities over the entire range of triaxialities that were approximately five per cent lower than the corresponding values of 24S-T. Preliminary analysis of sharply notched bars indicated that the notch ductility of the different alloys followed the same order as the ductility values derived for high degrees of triaxiality. Notch strength was reduced by sharp notches only for 24S-T, which may tentatively be correlated with its different stress-strain characteristics.

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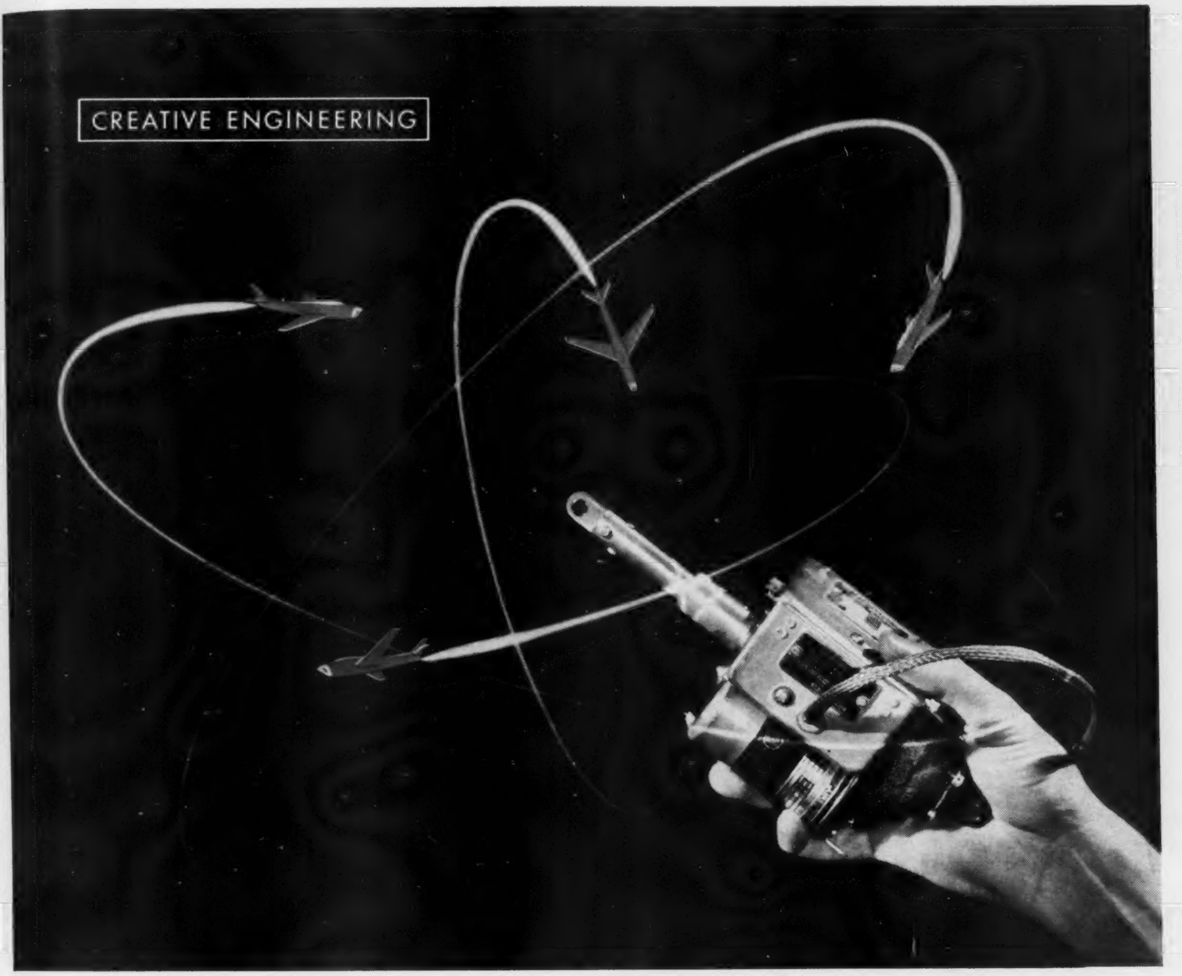
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Fatigue of Sandwich Constructions for Aircraft; Cellular Cellulose Acetate Core Material with Aluminum or Fiberglas-Laminate Facings, Tested in Shear. Fred Werren. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1559-F,* December, 1948. 10 pp., illus., fig.

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Navigation (29)

Notes on Astro Navigation in Polar Regions. F. E. Zaccheo. *Institute of Navigation, Journal*, Vol. 2, No. 2, April, 1949, pp. 180–183, figs.

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Parachutes

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Personal Flying (42)

An Analysis of the Economy and Utility of the Personal Airplane. Eugene W. Norris. *Aeronautical Engineering Review, Vol. 8, No. 6*, June, 1949, pp. 37–49, figs.

The economic factors that affect the economy and utility of personal aircraft and an analysis of the extent to which they are subject to the control of the airplane designer and of other factors that influence the acceptance and use of the personal airplane. A complete record of initial and operational costs was maintained over a 12-month period for a 90 hp. two-place all-metal conventional high-wing monoplane. Because of the change in the value of the dollar, the initial cost in 1948 was two-thirds of that in 1940. Improved performance developed during this period increased the airplane's relative monetary value as much as 185 per cent, for the four-place model. When used sufficiently for ends that are economically justifiable, operational costs can show a saving over other means of transportation. The net difference between auto and airplane operating costs with a utilization of over 5,000 miles per year is between $100 to $300. A major limitation on personal aircraft utilization is imposed by the ground transport phase of a trip. Properly fitted to the travel needs of the user and operating within its current limitations, the modern personal airplane is a highly versatile, efficient, comfortable, economical, and safe means of transportation.

Cutting the Cost of Private Flying; Attractions of the "Communal Group." David F. Ogilvy. *Flight*, Vol. 55, No. 2100, March 24, 1949, p. 349, illus.

Why Aren't More People Like Me Flying? E. O. Rushing. *Air Facts*, Vol. 12, No. 5, May 1, 1949, pp. 9, 10, 12–14.

Progress in Personal Aircraft. Herb Rawdon. *SAE Journal*, Vol. 57, No. 5, May, 1949, pp. 41–45, illus. (Extended summary of a paper: Personal Aircraft—Problems and Progress.)

Variety in Private Flying. *The Aeroplane*, Vol. 76, No. 1972, March 25, 1949, pp. 331–334, illus.

Personal Aircraft for Military Purposes. Part I—Background and History of Army Light Aviation. Claude L. Shepard. **Part II—The Current Army Light Aviation Procurement Program.** Richard L. Long. **Part III—Future Program.** David G. Cogswell. *Aeronautical Engineering Review*, Vol. 8, No. 7, July, 1949, pp. 24–29, illus. (Extended summary of a paper.)

Photography (26)

New Developments for Aerial Reconnaissance. George W. Goddard. *Photogrammetric Engineering,* Vol. 15, No. 1, March, 1949, pp. 51–72, illus., diagrs., figs.

New Developments in Photogrammetric Lenses. Irvine C. Gardner. *Photogrammetric Engineering,* Vol. 15, No. 1, March, 1949, pp. 36–50, illus., figs.

Antarctic Surveying. E. L. Merritt. *Photogrammetric Engineering,* Vol. 15, No. 1, March, 1949, pp. 15–22.

Canadian Air Survey; Its Problems and Future Outlook. Douglas N. Kendall. *Photogrammetric Engineering,* Vol. 15, No. 1, March, 1949, pp. 33–36.

Calibration of Photographic Lens Markings. *U.S., National Bureau of Standards, Technical News Bulletin,* Vol. 33, No. 4, April, 1949, pp. 50, 51, fig. 2 references.

Power Plants (4)

Performance Calculations; Mathematical and Graphical Solutions of Performance Calculations of Reciprocating-Engine and Reaction-Powered Aircraft. Franz Huber and Peter Kappus. *U.S., Air Force, Technical Report No. F-TR-1186-ND (ATI No. 27427),* February, 1949. 87 pp., figs.

Summary and the derivation and explanation of formulas and methods used by the Division of Developmental Studies of the Bavarian Motor Works (BMW), Munich, to calculate the performance of reciprocating and reaction-propulsion aircraft power plants. Charts and graphs are given for the graphical solution of problems in propeller efficiency, the variation of engine power output with altitude, and the calculation of take-off distance.

JET & TURBINE (5)

The Boeing 200-Hp. Gas Turbine and the Light Airplane. S. D. Hage. *Aeronautical Engineering Review,* Vol. 8, No. 7, July, 1949, pp. 30, 31, illus., diagr.

A semideveloped engine produced in the course of a program to support the development of a turbojet-driven bomber. It consists of a single-stage centrifugal compressor with two outlets and two constant pressure burners, a turbine to drive the compressor and accessories, and a free power turbine. Its weight, 150 lbs. without accessories, makes it suitable for light aircraft. It will have a power output between 100 and 200 b.hp. and a rated specific fuel consumption of from 1.5 to 1.0 lb. per b.hp-hr. Acceleration is rapid, the speed can be increased from idle to full speed in 5 sec. with practically no vibration.

Boeing Develops Small Gas-Turbine Powerplant. S. D. Hage. *SAE Journal,* Vol. 57, No. 4, April, 1949, pp. 40, 41, illus., fig. (Extended summary of a paper: The Boeing 200-Hp Gas Turbine.)

Boeing 200 h.p. Gas Turbine. S. D. Hage. *Shell Aviation News,* No. 130, April, 1949, pp. 22–24, diagrs., figs.

The Development of the Armstrong Siddeley Mamba Engine. W. H. Lindsey. *Royal Aeronautical Society, Journal, Vol. 53, No. 458,* February, 1949, pp. 137–173, Discussion, pp. 173–180, illus., diagrs., figs.

A history of the Mamba engine which details the changes incorporated in the Mamba 2. Major mechanical design modifications were the installation of a center bearing and the use of full depth teeth to eliminate tooth-meshing vibration in the reduction gear. The combustion chamber was adapted to burn vaporized instead of atomized fuel. The basic rating of the engine was raised to 1,260 hp. by redesign of the compressor and turbine to increase the air consumption by 26 per cent. Mamba power plants have been installed in the Boulton Paul Balliol Trainer, the Avro Athena Trainer, and Miles Marathon civil aircraft. The Mamba designed for the four-engine Armstrong Whitworth Apollo is described to show how the installation has been worked out to occupy minimum space and diameter consistent with ease of access and maintenance.

The Double-Mamba Power Group. *The Aeroplane,* Vol. 76, No. 1973, April 1, 1949, pp. 362–365, illus., diagrs., figs.

Turning Out The "Turbo-Wasp." Nathaniel F. Silsbee. *Aero Digest,* Vol. 58, No. 5, May, 1949, pp. 44–46, illus.

Inside the Nene. D. M. Desoutter. *Aeronautics, Special Trilingual Edition,* 1949, pp. 75–78, diagrs. (In English, French, and Spanish.)

Inside the Ghost. D. M. Desoutter. *Aeronautics, Special Trilingual Edition,* 1949, pp. 59–62, diagrs. Descriptions of the ghost engine's cascade vane assembly, combustion chambers, and accessory drive gear assembly.

French Turbo-Propeller and Turbo-Reaction Engines. P. Destival. *Royal Aeronautical Society, Journal,* Vol. 53, No. 458, February, 1949, pp. 111–131, Discussion, pp. 131–136, illus., diagrs.

Conception, design, and development of the TGA-bis turboprop and the TGAR 1008 turbojet engines by the S.O.C.E.M.A. In the TGA-bis, a single rotor is provided for the compressor and turbine carried by only two bearings that are made up of welded drum elements. The form of the compressor is unorthodox, but a calculated output and compression ratio and an efficiency of over 85 per cent were reached. Aspect ratio of the blades does not exceed three in the first stages. They are steel, stamped and milled, and are attached by a milled dovetail on a flat foot that is forged integrally with them. The turbine had to accurately balance the compressor thrust. This requirement determined the diameter and hence, the number of stages of the turbine, which worked out to be four. The most difficult problem was that of combustion. Atomization chambers were unknown. The required combustion rate with vaporized fuel was obtained by using a vaporization chamber to reduce the speed of the primary air-vaporized mixture to a value at which the flame remained anchored in the absence of deliberately provoked large-scale turbulence. The postwar TGAR 1008 turbojet's eight-stage axial compressor has an arrangement for surrounding the fixed blades of the turbine distributor with a layer of cold air, thus allowing the turbine to be worked at 900°C. without exceeding a blade temperature of 500°C. In order to improve functioning at lower r.p.m. and at higher altitudes, an atomization annular chamber, containing a number of cylindrical flame tubes of different diameters in which combustion takes place and which are disposed axially on two concentric pitch circles, allows the rear turbine bearings to be replaced by a front bearing. This is secured to the outer cylinder by crossed arms that lie between the flame tubes.

Automatic Control of Turbojet Engines. C. S. Cody. *American Society of Mechanical Engineers, Transactions,* Vol. 71, No. 2, February, 1949, pp. 175–184, illus., diagr., figs. 1 reference.

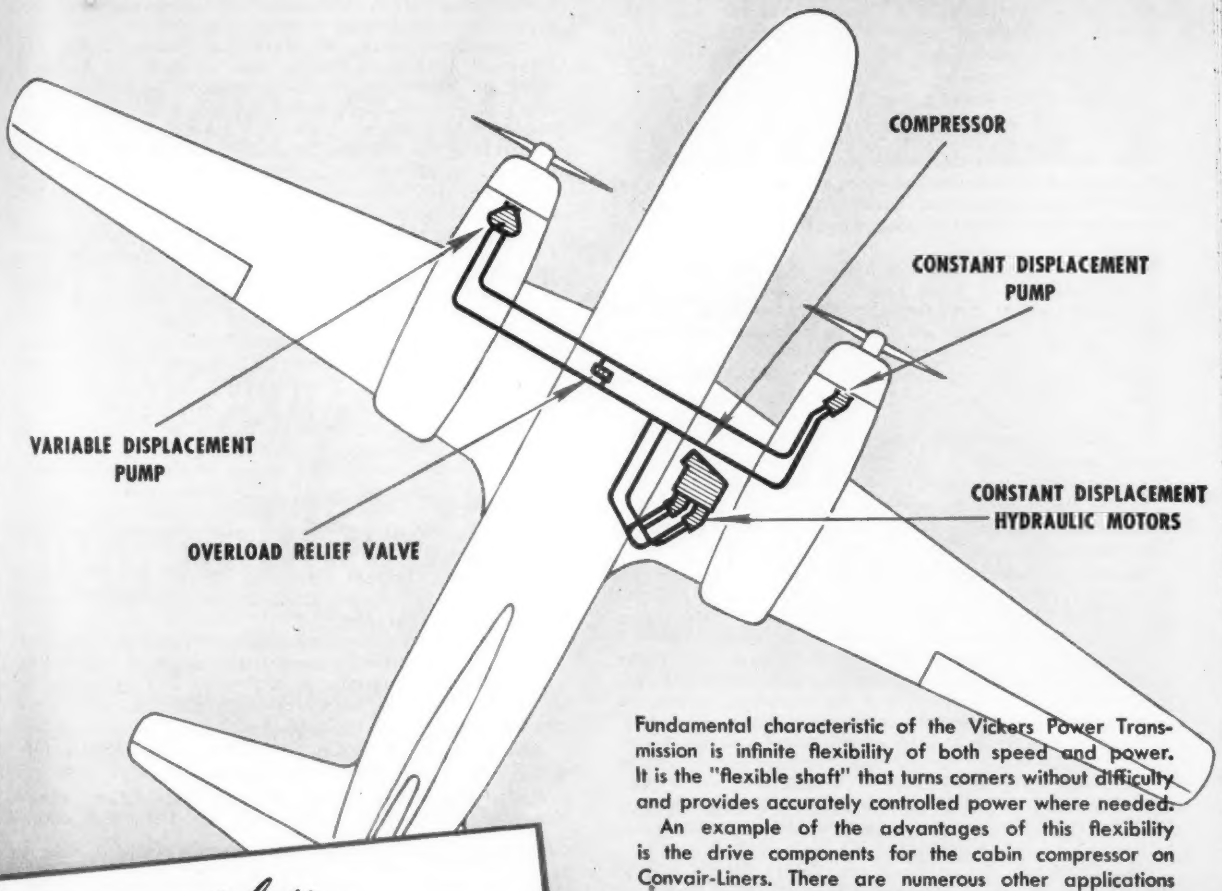
Based on engine operational experience and engineering design studies of control problems, acceleration controls, reliable mechanical design, and the incorporation of a variable-exhaust nozzle are considered to be primary requisites for optimum power control. Thrust is controlled by means of an all-speed isochronous speed-responsive governor in order to provide a more direct measurement than scheduled control, which established only an approximate relationship between fuel flow and flight conditions. The governor utilizes an error signal from the speed-sensing circuit and, with an automatic acceleration control that is sensitive to limiting conditions of stall, temperature, and combustor "blow-out," moves the throttle valve until a reset speed is reached. Mechanical design will consider packaging units to utilize internal passages instead of external fluid lines, the minimum pressure drops through the elements of the fuel-system, and a system that will operate satisfactorily with contaminated fuel. The advantages of the variable-area exhaust nozzle, maximum thrust for all flight conditions, fuel economy, and the ability to accelerate rapidly from low to high thrust must be weighed against reduced reliability, greater duct losses in the aircraft, and increased engine weight.

The Ramjet as a Supersonic Propulsion Plant. W. H. Goss and Emory Cook. *SAE Quarterly Transactions,* Vol. 2, No. 4, October, 1949, pp. 642–657, illus., figs. 10 references.

The ramjet features high power per unit frontal area and weight, high specific impulse, and excels all other power plants for sustained propulsion at supersonic speeds. Despite its mechanical simplicity, the ramjet presents a number of aerodynamic and thermodynamic problems. The study of these problems with full-scale models would require such an enormous amount of power that their solution must be found through improved understanding of the processes of flame stabilization at high flow velocities, mixing of gas streams, and combustion in general.

A Fundamental Consideration of the Supersonic Ramjet. Malcolm S. Harned. *Aero Digest,* Vol. 58, No. 4, April, 1949, pp. 44–47, 120, 121, figs. 3 references.

Note on Straight Pipe Jet Motors. Harold Grad. *Communications on Pure and Applied Mathematics,* Vol. 11, No. 1, March, 1949, pp. 71–77, figs. 1 reference.


COMPRESSOR
CONSTANT DISPLACEMENT PUMP
VARIABLE DISPLACEMENT PUMP
CONSTANT DISPLACEMENT HYDRAULIC MOTORS
OVERLOAD RELIEF VALVE

Investigation of flow and of the effect upon thrust of inserting a reagent at several points. The thrust is independent of the manner of introduction of the reagent whether it is inserted at many points or all at one point because the pressure at the closed end of the pipe depends on the total reagent added.

Performance Analysis of Centrifugal Compressors. Shao-Pan Liang. *Journal of the Aeronautical Sciences,* Vol. 16, No. 7, July, 1949, pp. 435–437, figs. 2 references.

Because elementary analyses of centrifugal compressors based on momentum and energy disregard friction loss in the impeller, experimental results do not confirm the conclusion that the energy received by each unit weight of gas compressed is solely a function of the tip speed of the impeller. In practice an increase in quantity of discharge reduces the pressure of delivery and affects compression efficiency. By treating the process as a combination of losing energy and adding heat an additional equation is obtained and by basing calculations on force and energy, performance may be predicted with reasonable accuracy.

Preliminary Performance Analysis of Gas Turbine Power-Plants. Ivan H. Driggs. *SAE Quarterly Transactions,* Vol. 2, No. 4, October, 1949, pp. 596–612, figs. 5 references.

Deviations from the ideal static sea-level operation of any engine design at any altitude and speed are determined on an enthalpy-entropy diagram from the increments of entropy produced by pressure losses through the system and by pressure gains due to velocity.

Gas Turbine Summary. William Morse. *Aeronautics,* Vol. 20, No. 5, April, 1949, pp. 32–35, illus.

The fundamentals of gas-turbine classification, and tables that illustrate their relationship to one another and show actual models that have been constructed.

Combustion in Moving Air. Frank R. Caldwell, Fillmer W. Ruegg, and Lief O. Olsen. *SAE Quarterly Transactions,* Vol. 3, No. 2, April, 1949, pp. 327–340, diagrs., figs. 10 references.

An outline of the problem presented by combustion in jet-engine combustors and a review of the results that have been attained in theoretical and experimental investigations.

Vapour Combustion Systems for Gas Turbine Engines. S. Allen. *Shell Aviation News,* No. 129, March, 1949, pp. 14–19, illus., figs.

Shielded Thermocouples for Gas Turbines. A. I. Dahl and E. F. Flock. *American Society of Mechanical Engineers, Transactions,* Vol. 71, No. 2, February, 1949, pp. 153–161, illus., diagrs., figs. 7 references.

Radiation from a thermocouple in the gas stream to the cooler walls of a turbine causes a spread in observed values of the gas temperature. Effective shielding of the measuring junction can be accomplished by pressing a small tubular shield of silver, gold, or platinum directly on an oxidized junction of base-metal thermoelements. The construction, calibration, and performance of junctions with pressed shields are described along with experimental determination of the rate of response of various junctions to sudden changes in temperature, and methods of increasing this rate.

Blade Checking. *Aircraft Production,* Vol. 11, No. 125, March, 1949, pp. 81–83, illus. Model 300 Pant-O-Scriber automatic turbine blade-inspection instrument.

Turbine-Blade Checking. *Aircraft Production,* Vol. 11, No. 126, April, 1949, p. 115, illus.

Cooler Turbines & Hotter Jets. Wei Chang Chu. *Aero Digest,* Vol. 58, No. 4, April, 1949, pp. 32, 116, 117, diagrs.

Introspection; Radiographic Inspection of Gas-Turbine Castings, Armstrong Siddeley Technique Described. *Flight,* Vol. 55, No. 2097, March 3, 1949, pp. 250, 251, illus.

Stress Investigations in Gas Turbine Discs and Blades. S. S. Manson. *SAE Quarterly Transactions,* Vol. 3, No. 2, April, 1949, pp. 229–239, illus., diagrs., figs. 5 references.

The Military Application of the Gas Turbine. F. R. Banks. *Aeronautics,* Vol. 20, No. 5, April, 1949, pp. 47–49.

Big Whoosh. *Steel Horizons,* Vol. 11, No. 2, 1949, pp. 24, 25, illus., diagr. A survey of the jet-engine production activity in the U.S.

Turbojet Powerplant for Supersonic Flight. George H. Wakefield. *Aero Digest,* Vol. 58, No. 5, May, 1949, pp. 70, 72, 74, 76, 121, 122, figs.

New Engines for High Speed Flight. II. Ben Lockspeiser. *Indian Skyways,* Vol. 3, No. 2, February, 1949, pp. 37, 38.

RECIPROCATING (6)

Preignition and its Deleterious Effects in Aircraft Engines. A. Hundere and J. A. Bert. *SAE Quarterly Transactions,* Vol. 2, No. 4, October, 1949, pp. 546–562, illus., figs. 15 references.

Engine failure resulting from preignition is more prevalent than that resulting from detonation. The spark plug is the most common source of preignition; combustion-chamber deposits are second in importance, and the exhaust valve is the least common source. Data on a wide range of fuel types indicate that the differences between fuels in preignition-limited performance are small compared with the differences between fuels in detonation-limited performance. The addition of tetraethyl lead decreases the tendencies to preignition by metallic hot spots, but this effect is offset completely by the formation of lead combustion-chamber deposits that will themselves cause preignition.

Engine Conditioning. V—Mechanical Phases. *Aviation Operations,* Vol. 11, No. 4, March, 1949, pp. 21–23, 44, 47, 48, 50, 52, 55, 56, diagrs. Checks for compression, engine valves, ignition timing and harness, spark plug installation, idle mixture and idle speed adjustment, and for a cold cylinder.

Increasing the Thermal Efficiencies of Internal-Combustion Engines. J. M. Campbell, D. F. Caris, and L. L. Withrow. *SAE Quarterly Transactions,* Vol. 3, No. 2, April, 1949, pp. 341–352, figs. 8 references.

Comparison of Several Methods of Predicting the Pressure Loss at Altitude Across a Baffled Aircraft-Engine Cylinder. Joseph Neustein and Louis J. Schafer, Jr. *U.S., N.A.C.A., Report No. 858,* 1946. 15 pp., illus., diagrs., figs. 8 references. U.S. Govt. Printing Office, Washington. $0.15.

Production of Air-Cooled Copper Heads for Bristol Sleeve-Valve Engines. I—Development of Design and Machining of the Copper Base. *Aircraft Production,* Vol. 11, No. 125, March, 1949, pp. 75–79, illus., diagrs.

Fuel Injection for Lightplanes. Kurt Rand. *Flying,* Vol. 44, No. 4, April, 1949, pp. 32, 33, 74, diagrs.

The Ex-Cell-O fuel-injection system avoids freezing carburetors by mixing gasoline and air in the engine cylinders. It consists of four basic units, a fuel meter and injection pump, an air metering throttle and control linkage, discharge lines, and atomizing nozzles.

High-Output Engines. R. J. S. Pigott. *SAE Quarterly Transactions,* Vol. 3, No. 2, April, 1949, pp. 207–214, illus., diagrs., figs. 7 references.

The b.m.e.p. of reciprocating engines can be increased by elimination of intake pressure losses, improvement in manifold design, installing a supercharger aftercooler and by cooling the piston, cylinders, exhaust valve, and bearings by a cooling system using high velocity coolants.

Aero Engines. *Aeronautics, Special Trilingual Edition,* 1949, p. 78. (In English, French, and Spanish.)

Rolls-Royce Power Plants. W. P. Calvert. *The Technical Instructor,* Vol. 4, No. 4, April, 1949, pp. 3–20, illus., diagrs., figs.

Gas Gobbler. Willard W. Marsh. *Boeing Magazine,* Vol. 19, No. 4, April, 1949, pp. 10, 11, illus. The Boeing single-point fueling system.

ROCKET (4)

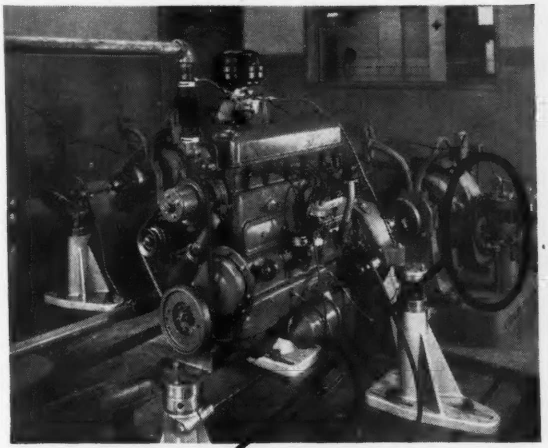
Resonance Burning in Rocket Motors. Harold Grad. *Communications on Pure and Applied Mathematics,* Vol. 11, No. 1, March, 1949, pp. 79–102, figs. 2 references.

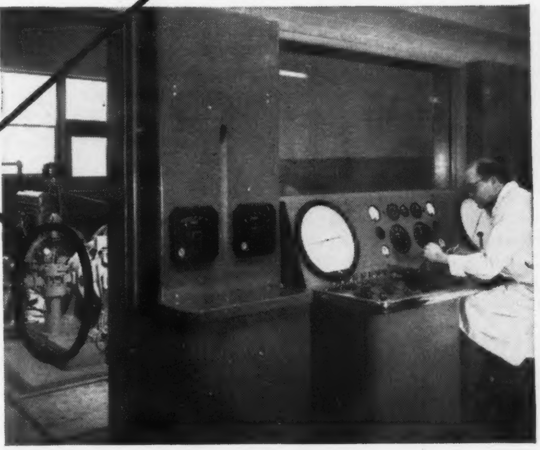
A qualitative mathematical theory to describe some of the principal irregularities in the burning of hollow powder grains that are most commonly observed as secondary pressure peaks in the combustion chamber. Partial differential equations and boundary conditions for the gas oscillations within the rocket combustion chamber are derived, and complex eigenvalues computed.

The Atomic Rocket—4. L. R. Shepherd and A. V. Cleaver. *British Interplanetary Society, Journal,* Vol. 8, No. 2, March, 1949, pp. 59–70. 1 reference.

Atomic Power and Aircraft Propulsion. Andrew Kalitinsky. *Aircraft,* Vol. 27, No. 5, February, 1949, pp. 17, 18, 42, diagrs. (Extended summary of a paper.)

Results of Afterburner Program; Such Tremendous Performance Gains Are Made Through Tailpipe Burning That Device Is Actually New Engine. Robert McLarren. *Aviation Week,* Vol.





50, No. 18, May 2, 1949, pp. 22, 24, 25, 27, 28, 32, illus., figs. 9 references.

Short-Range Airline Speed. L. H. W. Harris. *Flight*, Vol. 55, No. 2100, March 24, 1949, pp. 334, 335, illus.

Production (36)

New Sampling Plan Reduces Inspection Costs. *U.S., National Bureau of Standards, Technical Report No. 1348*, May, 1949. 4 pp.

How Chance Laws Cut Production Costs; Statistical Quality Control. *Aviation Week*, Vol. 50, No. 17, April 25, 1949, pp. 27, 28, 31, figs.

Stratification Control Charts. Irving W. Burr and Wade R. Weaver. *Industrial Quality Control*, Vol. 5, No. 5, March, 1949, pp. 10–15, figs.

Quality Control Charts for $\overline{X}$ and R Adjusted for Within-Subgroup Pattern. A. E. R. Westman and B. H. Lloyd. (Canada, National Research Council, Special Committee on Applied Mathematics and Statistics, Paper No. 3.) *Industrial Quality Control*, Vol. 5, No. 5, March, 1949, pp. 5–10, figs.

Design for Mass Production. O. A. Wheelon. *Machine Design*, Vol. 21, No. 3, March, 1949, pp. 135–138, illus., figs. Factors that control cost, the effect of design on the cost, and the distribution of costs in terms of design producibility.

We Stoop to Concur—On Costs. G. T. Willey. *The Martin Star*, March, 1949, pp. 14, 15, illus. The Facility Control Board of the Glenn L. Martin Company previews proposed purchases of material and equipment. During the past two years it has reduced expenditures by nearly $1,000,000.

S.B.A.C. Standards; Some Details of the Society's Co-ordinating Work for the Industry. *Aircraft Production*, Vol. 11, No. 125, March, 1949, p. 96.

Missiles to Reform Production. *Aviation Week*, Vol. 50, No. 17, April 25, 1949, p. 36.

Production Processes; Their Influence on Design. XLII—Production Brazing. Roger W. Bolz. *Machine Design*, Vol. 21, No. 3, March, 1949, pp. 107–114, illus., diagrs., figs.

New Precision Casting Process Provides Better Finish, Closer Tolerances. Herbert Chase and Leslie T. Schakenbach. *Materials & Methods*, Vol. 29, No. 3, March, 1949, pp. 52–56, illus. Procedure for using frozen mercury patterns in place of wax.

Poke Welding Offers New Method of Joining Stainless, Aluminum and Mild Steel. F. J. Pilia. *Materials & Methods*, Vol. 29, No. 3, March, 1949, pp. 64–67, illus.

Inert gas-shielded arc spot welding is used successfully in production on mild steels and stainless steels in thicknesses up to 0.078 in., and on aluminum alloys of types 2S, 3S, 52S, and 61S to 0.064 in. The trigger of a molded plastic hand gun is depressed momentarily to close the main contactor on the power supply to the welding transformer and to open a valve for the Argon gas. The gas is ionized by the high-frequency current, which is superimposed upon the welding circuit after the trigger is depressed to provide a path between the electrode and the workpiece for the 60-cycle welding current arc.

Portable Boring Head; Use for Machining Components After Assembly. *Aircraft Production*, Vol. 11, No. 125, March, 1949, p. 95, illus., diagr.

Three-Dimensional Routing (de Havilland Aircraft Company). *Aircraft Production*, Vol. 11, No. 126, April, 1949, pp. 111–114, illus., diagrs.

Tube-Bending; Combined Seat Headrest and Side-Members. *Aircraft Production*, Vol. 11, No. 126, April, 1949, p. 133, diagrs.

Martin Cuts a Plane-Building Corner to Turn Out Its First Six-Jet Bomber (XB-48) in Record Time. *Steel Horizons*, Vol. 11, No. 2, 1949, p. 29, illus.

Tool Planning Brings Production Economies (at the Glenn L. Martin Company). *Aviation Week*, Vol. 50, No. 11, March 14, 1949, p. 31.

The Nord Norecrin; Structure of the Most Widely Used French Post-War Light Aeroplane and the Manufacturing Methods at Les Mureaux. *Aircraft Engineering*, Vol. 21, No. 242, April, 1949, pp. 117–121, illus.

Building The Convair Liner. *Shell Aviation News*, No. 129, March, 1949, pp. 12, 13, illus.

Hermes IV and Hastings. II—Fuselage Frames, Phenolic Materials in Jig Construction, Bulkheads, Assembly of Floor Beams. S. C. Poulsen. *Aircraft Production*, Vol. 11, No. 125, March, 1949, pp. 86–94, illus., diagrs. Trading and manufacturing methods used by Handley Page for air frame components intended for out-of-fixture assembly.

Specialized Capacity; Precision and Craftmanship at a Famous Coventry Works. *Flight*, Vol. 55, No. 2100, March 24, 1949, pp. 352, 353, illus.

A Call on Canadair. II. H. F. King. *Flight*, Vol. 55, No. 2097, March 3, 1949, pp. 258–261, illus., diagr.

Propellers (11)

Free-Space Oscillating Pressures Near the Tips of Rotating Propellers. Harvey H. Hubbard and Arthur A. Regier. *U.S., N.A.C.A., Technical Note No. 1870*, April, 1949. 64 pp., illus., figs. 6 references.

Static tests for the effects on the free-space oscillating-pressure distributions of such parameters as propeller clearance, blade plan form, number of blades, blade loading, tip clearance, and tip Mach Number. Experimental data are compared with analytical results, and charts are calculated to enable a designer to estimate the average maximum free-space oscillating pressures in the critical region near the plane of rotation.

That Amazing "Aeromatic." Harris G. Moe. *Aero Digest*, Vol. 58, No. 5, May, 1949, pp. 32, 104, figs.

Airscrew Design Problems. *The Aeroplane*, Vol. 76, No. 1973, April 1, 1949, pp. 358–360, illus., diagr., figs. (Extended summary of a paper.)

Airscrew Design for Transport Aircraft; Some Basic Principles Reviewed. G. C. I. Gardiner and J. Mullin. *Flight*, Vol. 55, No. 2100, March 24, 1949, p. 354. (Extended summary of a paper: The Design of Propellers.)

Reference Literature (47)

First Flight Across the Atlantic. U.S. Air Services, Vol. 34, No. 5, May, 1949, pp. 9, 11, 12, 24.

Aviation and Society. William G. Key. *Air University Quarterly Review*, Vol. 2, No. 4, Spring, 1949, pp. 40–47.

Odom Sets Lightplane Record; Second Attempt in (Beech) Bonanza at 5,000-Mile Course from Honolulu to New York Is Completed in 36 hr., one min. *Aviation Week*, Vol. 50, No. 11, March 14, 1949, p. 16.

Two Flyers Remain Aloft for 1,008 Hours. *U.S. Air Services*, Vol. 34, No. 5, May, 1949, p. 17.

Rotating Wing Aircraft (34)

Response of a Helicopter Rotor to Oscillatory Pitch and Throttle Movements. Paul J. Carpenter and Herbert E. Peitzer. *U.S., N.A.C.A., Technical Note 1888*, June, 1949. 31 pp., figs. 4 references.

Measurements of drag-angle oscillation of a helicopter rotor were made to determine both the natural frequencies and the damping required to prevent excessive drag-angle movement. Methods of calculating both the symmetrical and unsymmetrical drag-angle frequencies are presented and the experimental results show fair agreement with the predicted values. The damping calculations show that the drag-hinge damping added to the system to prevent resonance caused by main-pitch or throttle movements should be approximately 35 per cent of the calculated critical.

The Operational Point of View. R. A. C. Brie. *Royal Aeronautical Society, Journal*, Vol. 53, No. 460, April, 1949, pp. 299–304, diagrs., figs.

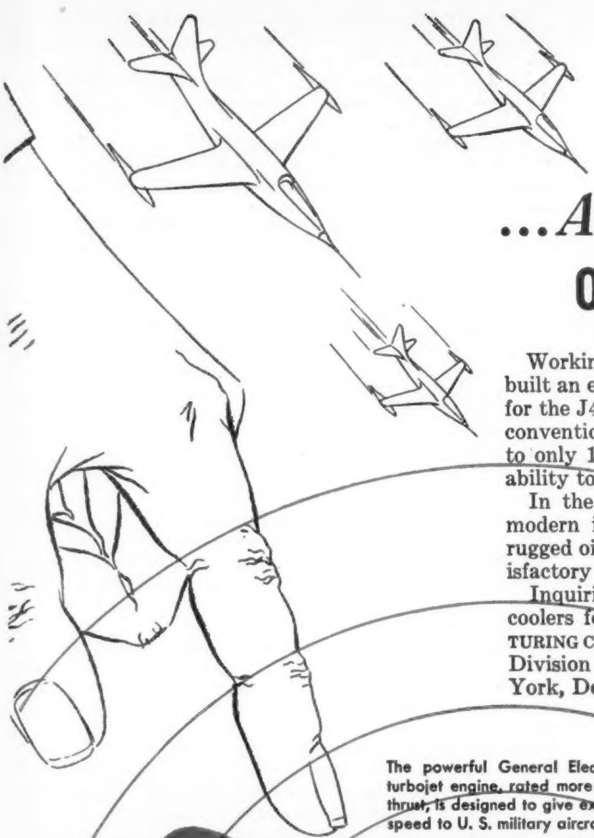
Although the present form of the helicopter is practical, further engineering development is necessary to obtain flight characteristics and to permit operational procedures that will ensure safety and reliability at an acceptable price.

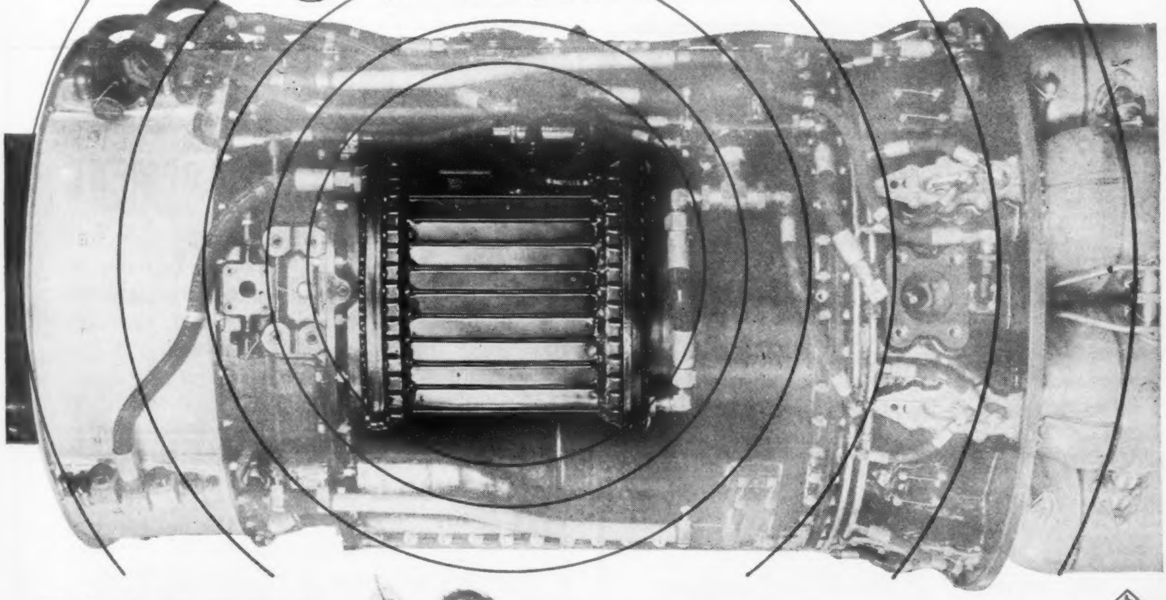
Accelerating Rotary Wing Development. John C. Vogtle. *American Helicopter*, Vol. 14, No. 5, April, 1949, pp. 16, 17.

Today's Picture in Helicopters. R. H. Prewitt. *American Helicopter*, Vol. 14, No. 4, March, 1949, pp. 8–10, 19, 20, figs. A survey of 73 helicopter models that were originated during the past two years or are in process of development.

The Case for the Large Helicopter (Cierva W.11). H. A. Marsh. *Shell Aviation News*, No. 129, March, 1949, pp. 10, 11, illus.

The Technical Problems of the Civil Helicopter. R. N. Liptrot. *Royal Aeronautical Society, Journal*, Vol. 53, No. 460, April, 1949, pp. 305–313. Vibration, simplification of control,






Instrument Bellows
Aircraft Bellows Assembly
Steam Trap Bellows Assembly
Bellows Seal Assembly
All-Aluminum Cylindrical Oil Cooler
All-Aluminum Oval Oil Cooler

stability, safety, and maintenance are the immediate problems to be investigated.

Attacking the Maintenance Problem Through Mechanical Design. Glidden S. Doman. *American Helicopter*, Vol. 14, No. 5, April, 1949, pp. 20, 21. (Summary of a paper.)

The Navigation of the Helicopter. R. W. Usher. *Helicopter Association of Great Britain, Journal*, Vol. 2, No. 2, July-August-September, 1948, pp. 25–37, diagrs. The probable utilization and instrumentation requirements of the helicopter.

The Bristol 171 Helicopter. R. Hafner. *Royal Aeronautical Society, Journal*, Vol. 53, No. 460, April, 1949, pp. 324–333, illus., figs. 2 references.

The Fairey Gyrodyne. J. A. J. Bennett. *Royal Aeronautical Society, Journal*, Vol. 53, No. 460, April, 1949, pp. 314–323, illus., diagrs. 2 references.

Helicopter Progress; Impressions of Flying in the Gyrodyne, Great Control Simplification, Some New American Types. *Flight*, Vol. 55, No. 2099, March 17, 1949, pp. 303–305, illus., diagr.

The Fairey Gyrodyne. J. A. J. Bennett. *Helicopter Association of Great Britain, Journal*, Vol. 2, No. 2, July-August-September, 1948, pp. 5–15, illus., diagrs.

Flying in the Fastest Helicopter (Fairey Gyrodyne). *The Aeroplane*, Vol. 76, No. 1971, March 18, 1949, pp. 302, 303, illus.

The Cierva Air Horse. J. S. Shapiro. *Royal Aeronautical Society, Journal*, Vol. 53, No. 460, April, 1949, pp. 334–368, illus., diagrs., figs.

Cierva's Air Horse. *The Aeroplane*, Vol. 76, No. 1974, April 8, 1949, pp. 388, 389, 392, 394, illus., figs.

Air Horse. I—Design Analysis of the Largest and Heaviest Helicopter in the World. *Flight*, Vol. 55, No. 2102, April 7, 1949, pp. 402–403, illus.

Air Horse. II—Control Features. *Flight*, Vol. 55, No. 2103, April 14, 1949, pp. 427–431, diagrs.

Doman to Construct Six Passenger Model (LZ-2A). M. Berry. *American Helicopter*, Vol. 14, No. 5, April, 1949, pp. 11, 17, 18, illus.

Latest American Helicopter; Piasecki XHJP-1 (Tandem Rotor). *Flight*, Vol. 55, No. 2100, March 24, 1949, p. 341, illus.

Copter Sets World Speed Record; Sikorsky S-52-1 Establishes Rotary-Wing Craft Mark of 129.616 m.p.h. *Aviation Week*, Vol. 50, No. 19, May 9, 1949, p. 17, illus.

XA-5 (American Helicopter Co.) Top Sergeant—New Pulse-Jet 'Copter. J. W. Bunkley. *American Helicopter*, Vol. 14, No. 4, March, 1949, pp. 6, 7, 19, illus.

Pod-Copter Design Accents High Utility; Proposal for Rotorcraft to be Hauled by C-120 Type Embodies Rescue, Cargo, Crane, Transport Features. *Aviation Week*, Vol. 50, No. 15, April 11, 1949, pp. 24, 25, diagrs.

Comparisons of Current Helicopter Configurations. R. H. Prewitt. *SAE Journal*, Vol. 57, No. 5, May, 1949, pp. 67, 68, figs. (Extended summary of a paper.)

Convertible Aircraft. Alexander Klemin. *Aero Digest*, Vol. 58, No. 4, April, 1949, pp. 52, 53, 114, illus.

New Russian Aircraft Revealed. *Aviation Week*, Vol. 50, No. 16, April 18, 1949, pp. 20, 21, illus. The Kamov Vertolet, Bratukhin helicopter and the fixed wing trainer, Yak-11.

Notes on Flight Testing Helicopter Power Plant Cooling Systems. W. E. Cobey. *American Helicopter*, Vol. 14, No. 5, April, 1949, p. 8.

Rotor Drives; An Examination of Helicopter Transmission Systems. *Flight*, Vol. 55, No. 2097, March 3, 1949, pp. 248, 249, diagrs.

Jet-Propelled Helicopter Rotors. Alexander Klemin. *Aero Digest*, Vol. 58, No. 5, May, 1949, pp. 66–68, 119–121, illus.

Navy School for Helicopter Pilots. Richard L. Wiskerchen. *American Helicopter*, Vol. 14, No. 4, March, 1949, pp. 13, 14, 22, illus.

Pest Control in Great Britain and Africa. J. E. Harper. *American Helicopter*, Vol. 14, No. 5, April, 1949, pp. 6, 7, 17, illus.

New Technique for Fighting Forest Fires. Starr Jenkins. *American Helicopter*, Vol. 14, No. 4, March, 1949, pp. 15, 16, 22, 23, illus.

Fighting Africa's Tsetse Fly. *The Bee-Hive*, Vol. 24, No. 2, Spring, 1949, pp. 15, 16, illus.

Helicopter Night Mails. *The Aeroplane*, Vol. 76, No. 1969, March 4, 1949, pp. 250, 251, illus.

Pilot-training technique, navigational aids, and other experimental measures used to maintain a night mail schedule between Peterborough and Norwich with B.E.A.'s Westland-Sikorsky G-AJOV.

Helicopter Night Mail; B.E.A. Peterborough-Norwich Experimental Service. *Flight*, Vol. 55, No. 2098, March 10, 1949, pp. 283–285, illus.

Link Between Air and Ground Transport. *Indian Skyways*, Vol. 3, No. 2, February, 1949, pp. 49, 50.

Sciences, General (33)

MATHEMATICS

Lame's Wave Functions of the Ellipsoid of Revolution. J. Meixner. (*ZWB Forschungsbericht Nr. 1952, June, 1944.*) *U.S., N.A.C.A., Technical Memorandum No. 1224*, April, 1949. 102 pp., tables. 15 references.

Improving Analysis of Graphical Records. James Martin and J. H. Meier. *Machine Design*, Vol. 21, No. 3, March, 1949, pp. 115–119, figs. 2 references. Practical formulas for computing the derivatives of curves for which mathematical functions are unknown.

Structures (7)

Note on the Relations Between Viscous and Structural Damping Coefficients. Walter W. Soroka. *Journal of the Aeronautical Sciences*, Vol. 16, No. 7, July, 1949, pp. 409, 410, 448. 3 references.

The use of the structural damping factor g in vibration problems implies that the damped free vibration frequency of the structure increases with damping. Relations are derived comparing the natural frequencies and logarithmic decrements for viscous and structural damping. For low values of damping (up to $g = 0.20$), the two concepts give nearly the same results when g is taken as twice the critical viscous damping ratio.

Fatigue. P. B. Walker. *Flight*, Vol. 55, No. 2102, April 7, 1949, p. 400. (Extended summary of a paper: *Fatigue in Aircraft Structures*).

Theories of Plastic Buckling. S. B. Batdorf. *Journal of the Aeronautical Sciences*, Vol. 16, No. 7, July, 1949, pp. 405–408, figs. 15 references.

A new theory of plasticity is based upon the concept of slip. Its formulation was guided more by the physical and less by the mathematical considerations than were the flow or deformation theories. Experimental evidence, although of limited scope, is of crucial character and is in better agreement with the new theory than with previous theories for the polyaxial stress-strain relations beyond the elastic range. It accounts for the apparent contradictions between the flow and the deformation theories and justifies the use of the latter in analyzing the plastic buckling of plates.

On a Question of Hadamard Concerning Super-Biharmonic Functions. R. J. Duffin. *Journal of Mathematics and Physics*, Vol. 27, No. 4, January, 1949, pp. 253–258. 4 references.

Whether a perpendicular force is applied at some point of a thin flat elastic plate that is rigidly clamped on its boundary produces the displacement of the plate that is of one sign at all points.

Compressive Buckling of Flat Rectangular Metalite Type Sandwich Plates with Simply Supported Loaded Edges and Clamped Unloaded Edges. Paul Seide. *U.S., N.A.C.A., Technical Note No. 1886*, May, 1949. 19 pp., figs. 8 references.

The Elastic Equilibrium of Isotropic Plates and Cylinders. A. E. Green. *Royal Society of London, Proceedings, Series A*, Vol. 195, No. 1043, February 3, 1949, pp. 533–552. 9 references.

Critical Shear Stress of Infinitely Long, Simply Supported Plate With Transverse Stiffeners. Manuel Stein and Robert W. Fralich. *U.S., N.A.C.A., Technical Note No. 1851*, April, 1949. 39 pp., illus., figs. 8 references.

A theoretical solution for the critical shear stress of an infinitely long simply supported flat plate with identical equally spaced transverse stiffeners of zero torsional stiffness. Results obtained by the Lagrangian multiplier method are presented in design charts. Experimental results agree with theory.

Stress Distribution Near Reinforced Circular Hole Loaded by Pin. Samuel Levy and Frank C. Smith. *U.S., National Bureau of Standards, Journal of Research*, Vol. 42, No. 4, April, 1949, pp. 397–404, illus., figs. 8 references. (Available also as Research Paper No. RP1979. U.S. Govt. Printing Office, Washington. $0.10.)

A theoretical analysis for the stress distribution in a flat plate near a reinforced circular hole loaded by a pin and a comparison of the theory with test results for a plate of sandwich construction. It is assumed that an auxiliary reinforcement at the edge of the hole is so rigid that no distortion of the shape of the hole occurs due to the load. The plate is reinforced in the vicinity of the hole by circular "doubler" plates. The theory and experiment are found to be in good agreement.

Critical Axial-Compressive Stress of a Curved Rectangular Panel with a Central Longitudinal Stiffener. Murry Schildcrout and Manuel Stein. *U.S., N.A.C.A., Technical Note No. 1879*, May, 1949. 18 pp., figs. 5 references.

Centrifugal Stresses in Disks; Graphical Determination Simplifies Analysis. Frank Beck. *Machine Design*, Vol. 21, No. 5, May, 1949, pp. 137–143, figs. 2 references.

A Study of the Bending-Torsion Aeroelastic Modes for Aircraft Wings. Martin Goland and Yudell L. Luke. *Journal of the Aeronautical Sciences*, Vol. 16, No. 7, July, 1949, pp. 389–396, figs. 9 references.

This manner of arriving at the stability determinant for natural motions of a bending vs. a torsion aeroelastic system permits determination of the natural modes of the system at any chosen air speed. The damping in the critical mode increases with air speed until at least 85 per cent of the critical speed is reached; it then decreases rapidly to the flutter value of zero. Comparison between normal mode characteristics and system response to forced excitation shows that the latter usually affords an earlier indication of the approach of critical flutter and is therefore a preferable method of flight-flutter testing.

Loads on a Supersonic Wing Striking a Sharp-Edged Gust. M. A. Biot. *Journal of the Aeronautical Sciences*, Vol. 16, No. 5, May, 1949, pp. 296–300, 310, diagrs., figs. 1 reference.

Calculation of the chordwise lift distribution, total lift and moment on a two-dimensional wing striking a sharp-edged gust at supersonic speed. Both the direct solution established by considering a distribution of sources in a fluid at rest and a method using Busemann's conical flow can be used. The time history of the total lift and mid-chord moment show that the total lift increases with time and reaches a maximum that corresponds to the steady-state phase of the flow. The mid-chord moment goes through a maximum independent of the Mach Number if the latter value is larger than $4/\pi$, while this maximum can become infinite for a range of Mach Numbers between $4/\pi$ and 1.

A Physical Theory of Supersonic Aerofoils in Unsteady Flow. W. J. Strang. *Royal Society of London, Proceedings, Series A*, Vol. 195, No. 1041, December 7, 1948, pp. 245–264, figs. 5 references.

The linearized theory of thin two-dimensional supersonic airfoils in unsteady motion in a form that brings out its full physical significance has been omitted by previous investigators who, because of their interest in flutter applications, concentrated on periodic solutions which offered little insight into the physical processes involved. Solutions for point and line sources are given for the transient case in both stationary and moving coordinate systems, and are integrated to give the solutions for a supersonic airfoil entering a sharp-edged gust and for a supersonic airfoil following a sudden change of incidence. Oscillatory solutions from a sudden change of incidence check with those of previous investigators. The results of some calculations on the entry of supersonic aircraft into gusts are in nondimensional form and cover a wide range of speeds, wing loadings, and gust profiles.

Calculation of the Aerodynamic Loading of Flexible Wings of Arbitrary Plan Form and Stiffness. Franklin W. Diederich. *U.S., N.A.C.A., Technical Note No. 1876*, April, 1949. 52 pp., figs. 8 references.

The Flutter of Servo-Controlled Aircraft. Jonathan Winson. *Journal of the Aeronautical Sciences*, Vol. 16, No. 7, July, 1949, pp. 397–404, figs. 4 references.

Control surface motion under locked-stick condition is, in the servo-controlled aircraft, an expression of the reaction of the highly complex servomechanism to external disturbance. The mechanism is usually nonlinear and difficult to treat mathematically. This solution for flutter uses experimentally determined characteristics of servo unit to predict flutter. Impedance of the servo and related elastic structure is obtained by test. These values, when compared to a set of theoretical flutter bound-

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ary curves that are functions of the aircraft parameters, yield a complete understanding of the flutter characteristics of the aircraft.

Proposal for an Airworthiness Requirement Referring to Symmetrical Gust Loads. J. H. Greidanus and A. I. van De Vooren. *Amsterdam, National Luchtvaartlaboratorium, Report No. F. 45,* February 10, 1949. 14 pp., figs. 4 references.

An analysis of gust-load calculations made by the Dutch Aeronautical Authority shows that apart from transient overstresses an acceptable approximation of gust-loads can be derived from four conditions of aerodynamic loading. Each condition is determined by a steady angle of attack of the whole aircraft and augmented with respect to the condition of undisturbed steady horizontal flight by an alleviating factor. This criterion is proposed to replace the recommendations in the PICAO Doc. 3031, articles 3.3.1.4.4 and 3.3.1.4.5. Proposed 1947 Edition of Airworthiness Standards and Recommended Practices.

Flutter and Oscillating Air-Force Calculations for an Airfoil in a Two-Dimensional Supersonic Flow. I. E. Garrick and S. I. Rubinow. *U.S., N.A.C.A., Report No. 846,* 1946. 25 pp., figs. 7 references. U.S. Govt. Printing Office, Washington. $0.20.

A summary of the Possio's theory of nonstationary flow for small disturbances in a two-dimensional supersonic flow and its application to an oscillating airfoil of infinite aspect ratio moving at supersonic speed. The treatment is extended to establish the equations of motion and the determinantal equation for the flutter condition, to calculate the aerodynamic forces on an oscillating airfoil and on a wing in bending-torsion flutter, and to obtain the critical speeds for wing divergence and aileron reversal.

Flutter Hunters. Louis R. Huber. *Boeing Magazine,* Vol. 19, No. 4, April, 1949, pp. 6, 7, illus.

Weight Estimation of Metal Wings. G. K. Gates. *Aircraft Engineering,* Vol. 21, No. 242, April, 1949, p. 116, fig.

Thermodynamics (18)

On the Second Law from the Standpoint of the Equation of State. J. L. Finck. *Discussion.* Prigogine and P. Van Rysselberghe. Author's Reply. *Franklin Institute, Journal,* Vol. 247, No. 5, May, 1949, pp. 497–503. 17 references.

Water-Borne Aircraft (21)

Wave Profile of a Vee-Planning Surface, Including Test Data on a 30-Degree Deadrise Surface. B. V. Korvin-Kroukovsky, Daniel Savitsky, and William F. Lehman. *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Preprint No. 229,* April, 1949. 50 pp., illus., figs. 6 references. $1.60.

A nomograph for estimating afterbody planing area for various planing conditions is developed from an empirical equation that was obtained from an analysis of all the longitudinal centerline profiles of a series of 10°, 20°, and 30° deadrise prismatic planing surfaces. The longitudinal centerline profile is the most important factor in determining the afterbody wetted area. Data are given for transverse and longitudinal sections through the wake at various forward speeds and loadings with trims of 4, 8, and 12 degrees. The general shape and features for all three deadrise planing surfaces are basically similar. A reduction in deadrise angle slightly reduces the height of the longitudinal centerline profile but it does not materially affect the relation between change in wave height and change in aspect ratio or load coefficient.

Effect of Increase in Afterbody Length on the Hydrodynamic Qualities of a Flying-Boat Hull of High Length-Beam Ratio. Walter J. Kapryan and Eugene P. Clement. *U.S., N.A.C.A., Technical Note No. 1853,* April, 1949. 31 pp., illus., diagrs., figs. 6 references.

Determination of the trim limits of stability, the range of position of the c.g. for take-off, the landing stability, the spray characteristics, the excess thrust for take-off, and the impact accelerations and behavior during landings in waves equivalent, for full size craft, to 4 ft. In general, extending the afterbody improved the hydrodynamic qualities of the seaplane.

Determining the Hydrodynamic Characteristics of Flying Boats. F. W. S. Locke, Jr. *Aircraft Engineering,* Vol. 21, No. 242, April, 1949, pp. 104–112, illus., diagrs., figs.

Testing techniques that correlate numerical data and the sensations experienced by pilots have been developed which replace motion-picture records of instrument panels and oscillograph records. The techniques reduce the time required for data analysis and provide quantitative data on low speed maneuverability, prehump directional stability, longitudinal stability during take-off and landing in smooth water, and rough water landing behavior.

New Hull Fineness Slashes Drag; Remarkable Reduction in Form Resistance Eliminates Classic Inequality, Makes Flying Boat Competitive with Landplane. Robert McLarren. *Aviation Week,* Vol. 50, No. 11, March 14, 1949, pp. 22, 23, 25–27, illus.

Remote-Control Model (XPSY-1) Seaplane Used to Gather Performance Characteristics on Larger Craft. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest,* Vol. 14, No. 6, March 15, 1949, pp. 11, 12.

The Fulton Airphibian. *Air World,* Vol. 1, No. 6, April, 1949, p. 148, illus.

New Flying Boat (Convair XP5Y-1) Rolled Out. *Aviation Week,* Vol. 50, No. 17, April 25, 1949, p. 13, illus.

Advanced Amphibian (Vickers Supermarine Seagull). *Aeronautics,* Vol. 20, No. 5, April, 1949, pp. 36, 37, illus.

Wind Tunnels (17)

Investigation with an Interferometer of the Turbulent Mixing of a Free Supersonic Jet. Paul B. Gooderum, George P. Wood, and Maurice J. Brevoort. *U.S., N.A.C.A., Technical Note No. 1857,* April, 1949. 65 pp., illus., diagrs., figs. 11 references.

An instantaneous record from which can be calculated the variation of gas density throughout a flow field, is given by a Mach-Zehnder type of interferometer. There was similarity in density distribution at the cross sections investigated. The velocity distributions through the mixing region also resembled each other and in the subsonic portion were similar to Tollmien's theoretical velocity distribution. The rates of spread of the mixing zone, both into the jet and into the ambient air, were less than those of subsonic jets.

Subsonic Two-Dimensional-Flow Conditions Near an Airfoil Determined by Static Pressures Measured at the Tunnel Wall. Bernard N. Daley and Lillian E. Hanna. *U.S., N.A.C.A., Technical Note No. 1873,* April, 1949. 45 pp., illus., figs. 11 references.

The possibility of measuring flow-field pressures by means of orifices in the tunnel wall and of comparing experimental with theoretical values. Measurements of static pressures in the neighborhood of N.A.C.A. 66,2-015 and 66, 2-215 airfoils in two-dimensional flow were made by means of orifices in the model end plate that was fitted flush with the tunnel wall. The flow-field pressures measured at the wall, when judged by their relation to the midspan surface pressures, appeared to be reasonably representative of conditions at the midspan location in the field, except when steep pressure gradients or flow separation were encountered.

Wall Corrections for a Two-Dimensional Electrical Tank. J. Sanders. *Canada, National Research Council, Division of Mechanical Engineering, Aerodynamics Laboratory, Report No. MA-213,* November 23, 1948. 40 pp., figs. 8 references.

The problem of a thin airfoil in a two-dimensional tank is solved by introducing images of the airfoil on the sides of the tank. The potential image of these images is written as Theta-functions in order to obtain the velocity induced by the walls in the neighborhood of the airfoil. The effect of this induced velocity is found by means of thin airfoil theory.

Optical Glass of Interferometer and Schlieren Quality for Wind-Tunnel Optics. Leroy W. Tilton. *U.S., National Bureau of Standards, Journal of Research,* Vol. 42, No. 3, March, 1949, pp. 279–286. 22 references. Available also as Research Paper No. RP1969. U.S. Govt. Printing Office, Washington. $0.10.

Wind-tunnel optics should be uniform in optical thickness within $\pm 1/16\ \lambda$, and heterogeneities should be less than $\pm 5 \times 10^{-7}$ in refractive index for thicknesses of 3 or 4 cm. Different chemical composition and stress birefringence have little effect on optic efficiency. However, temperature gradients during annealing can cause change in structure. This can be reduced by encasing the glass during annealing in a number of concentric boxes composed of alternately heat-conducting and insulating layers.

Aeronautical Reviews

Books

Gas Turbines for Aircraft

By F. W. Godsey, Jr., and Lloyd A. Young. McGraw-Hill Book Company, 1949. 355 pages, 238 figures.

The aircraft gas turbine is old and simple in principle, complex and difficult in execution. Within the last 9 or 10 years, many excellent papers on the subject have appeared. Now a synthesis has become imperative and Messrs. Godsey and Young have provided such a synthesis. It is fortunate for the development of the gas turbine that so solid and scholarly a book has appeared.

Chapter 1 on Basic Aerodynamics of Aircraft does the best it can in some 27 pages, but has little importance. Chapter 2 on Aircraft Propulsion is even shorter but more useful, since it establishes so well the idea of efficiency in thermal jets, while reviewing the fundamentals of the propeller.

But it is in Chapter 3 on Gas Flow that the authors really get to work. There is now available an enormous literature on high-speed gas flow. Its very extensiveness is a drawback. In Chapter 3, the engineer or student will find within a few pages practical formulas and data that he needs for problems in duct flow with heating or cooling, gas flow with boundary friction, ram flow into ducts, the effect of normal and oblique shocks. There are few derivations, which is a drawback from the college point of view, but there is everything the design engineer needs in small compass.

The same remarks apply to Chapter 4, Aircraft Gas Turbine Compressors with a minimum of derivations it is possible to review quickly the overall theory and status of the compressor (centrifugal and axial), to dig out fundamental relationships, and to relate curves of efficiency and capacity to every operating condition. What more could one ask in fitting a compressor to the engine or in the preliminary stages of compressor design? The same complimentary remarks apply to Chapter 6, Turbines and Their Characteristics, where, in addition to the thermodynamics and dynamics of the subject, we read instructive pages on temperature and stress and composition of turbine blades.

In Chapter 5, Fuels and Burners, the engineer will be delighted with such useful charts as: enthalpy correction factor for combustion products in air; temperature rise for constant pressure; 100 per cent combustion of different fuels in air plotted against fuel/air ratio; combustion space pressure losses, etc.

Chapter 7, The Jet Nozzle, gives all the necessary equations for thrust in supersonic jet flows and discusses details of design.

Chapters 8 and 9, Gas Turbine Cycles, and Variants of Simple Gas-Turbine Cycles, have much in them; a man well versed in this topic will know how to use them. Someone not so familiar with the subject matter will find the treatment a trifle too condensed. The processes of turbine performance calculations cannot be dismissed quite so rapidly, and a careful reader will want to go to original sources.

Chapter 10, Aircraft Gas Turbine Accessories and Controls, describes clearly starters, lubrication system, fuel system, controls, etc. This chapter is an ideal introduction to the Installation Manuals for Aircraft Gas Turbines that the manufacturers will be distributing to their customers sooner or later.

Chapter 11, on Present Development Status of Gas Turbines for Aircraft, has as its most important feature a tabulation of current (U.S. and British) Gas Turbines for Aircraft. There is real utility in such a tabulation. It shows where we stood when the book was written and will furnish a basis of comparison for the much more powerful and efficient turbojets to come. We like also the curves (projected to 1952) of thrust per unit frontal area, specific fuel consumption, and engine specific weight.

No one could have selected a better series of charts for the Appendix, covering as they do Thermodynamic Properties of Air, Enthalpy Fuel Corrections, Heat Exchange, The Gas Constant Related to Fuel/Air Ratio, etc.

This is a book which every practicing engineer in this field will want to read and use without hesitation, and with great satisfaction. It will not fit so well the needs of Senior students in our colleges for whom a more fundamental and theoretical approach is needed, but Graduate students in modern aircraft power plant design will find the book a godsend. It is hardly necessary to add that everything written is accurate and authoritative.

Dr. Alexander Klemin
Consulting Engineer
Greenwich, Conn.

Book Notes

AVIATION MEDICINE

Industrial Hygiene and Toxicology. Vol. I. Frank A. Patty, editor. New York, Interscience Publishers, Inc., 1948. 531 pp., figs. $10.

Contents: Industrial Hygiene—Retrospect and Prospect, by Frank A. Patty; Industrial Hygiene Records and Reports, by John B. Littlefield; The Industrial Hygiene Survey and Personnel, by Frank A. Patty; Personal Factors in Competence and Fatigue, by Josef Brozek; Environmental Factors in Fatigue and Competence, by W. N. Witheridge; Physiological Effects of Abnormal Atmospheric Pressure, by Heinz Specht; The Mode of Entry and Action of Toxic Materials, by Frank A. Patty; Sampling and Analysis of Atmospheric Contaminants, by Frank A. Patty; Radiant Energy and Radium, by Leon F. Curtiss; Ventilation, by W. N. Witheridge; Occupational Dermatoses, by Louis Schwartz; The Visible Marks of Occupation and Occupational Diseases, by Carey P. McCord; Fire and Explosion Hazards of Combustible Gases and Vapors, by G. W. Jones; Explosion and Fire Hazards of Combustible Dusts, by Irving Hartmann; Respirators and Respiratory Protective Devices, by Frank A. Patty; and Dust and Its Role in the Causation of Occupational Diseases, by Edward E. Dart.

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Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

EDUCATION AND TRAINING

A Survey of Collegiate Courses in Aviation and Related Fields. 3rd Edition. Prepared for and with the cooperation of the Civil Aeronautics Administration by the American Council on Education. Washington, Civil Aeronautics Administration, Aviation Training Staff, October, 1948. 61 pp.

In this edition 331 colleges are represented, of which 43 give 4-year courses in Aeronautical Engineering, 18 give 4-year courses in Mechanical

Engineering with aeronautical option, and 12 give 4-year courses in Aviation Administration.

First Steps in Engineering for the Apprentice. Major G. McAlpine. London, Percival Marshall & Co. Ltd., 1949. 43 pp., figs. 3*s*.

The author addresses himself to those interested in craftmanship and practical engineering. A principal reason for this book is to encourage entrance into apprenticeships. Processes of learning precision engineering, instrument making, tool making, and other engineering trades are discussed with emphasis on practical steps, such as choice of a school or company, as well as technical steps.

ELECTRONICS

Maintenance Manual of Electronic Controls. Robert E. Miller, editor. New York, McGraw-Hill Book Company, Inc., 1949. 304 pp., figs. $4.50.

This book is intended to be a practical manual for the installation, maintenance, and servicing of industrial electronic control equipment including the cathode-ray oscilloscope, electronic relays and timing relays, photoelectric relays, electronic motor control, electronic resistance-welding control, electronic temperature-control systems, and sealed-ignition rectifiers. The chapters are based on a series of articles published in *Electrical Construction and Maintenance*.

Reference Data for Radio Engineers. 2nd Edition. New York, Federal Telephone and Radio Corp., 1946. 335 pp., diagrs. $2.00.

This compilation is designed for quick reference use, and the data are presented by extensive use of tables, formulas, and graphs. The entire field of radio is covered, including materials, audio and radio design, rectifiers and filters, iron-core transformers and reactors, vacuum tubes, vacuum tube amplifiers, transmission lines, wave guides, propagation and noise, antennas, and wave-forms. A number of mathematical tables and tables of general information are included.

ENGINEERING PRACTICES & AIDS

Dimensions in Engineering Theory. G. W. Stubbings. London, Crosby Lockwood & Son Ltd., 1948. 107 pp. 7*s*. 6*d*.

Designed for the elementary student and the practical engineer this book is intended to fill the need for a small work dealing entirely with dimensions and their applications in engineering. Following a discussion of fundamental units there are two chapters on the elementary theory of dimensions and on applications of the theory. The use of an auxiliary dimensional symbol in rotational dynamics is explained as a way of handling problems involving such dissimilar quantities as torque and work. A special dimensional symbol for temperature is recommended and its use explained. The final chapter deals with dimensions of electrical quantities including dimensions of permittivity and permeability.

LAWS & REGULATIONS

Handbook of Patents. Harry Aubrey Toulmin, Jr. New York, D. Van Nostrand Co., Inc., 1949. 800 pp. $9.00.

The author aims to present a guide to the steps that must be taken to investigate the novelty of an idea, prepare a patent application, follow it through to an issued patent, and protect it in the courts. The patent law and the patent system, and their relation to manufacturing and research and engineering are discussed in the first chapters. Patent rights abroad, foreign patents in the United States, and international treaties and conventions to which the United States is a party are included. The texts of patent laws, rules of practice of the United States Patent Office, and selected rules of the United States Court of Customs and Patent Appeals are given in appendixes. The book is thoroughly indexed.

MANAGEMENT AND FINANCE

Formula for Supervision; Outlining the Application of Supervisory Control to Secure Safe, Efficient Work Performance. H. W. Heinrich.

Deep River, Conn., National Foremen's Institute, Inc., 1949. 95 pp. $1.00.

The purpose of this book is to outline a system for the solution of supervisory problems, particularly in the prevention and correction of faults and errors. The approach is simplified, and the book is intended for use with or without class-room study.

How to Do Business with the U.S. Government. Oliver Hoyem. New York, Oliver Durrell Inc., 1949. 288 pp. $5.00.

This book covers the operation of various branches of the government, publications and forms useful to the manufacturer and business man, and recommended steps and observations in preparing to do business with government agencies. It is well informed and practical and brings together much on the procedure of selling to the government, which was not previously available in one book.

MATERIALS

Steel and Its Heat Treatment. Volume III. Engineering and Special-Purpose Steels. 5th edition. D. K. Bullens and The Metallurgical Staff, Battelle Memorial Institute. New York, John Wiley & Sons, Inc., 1949. 606 pp., diagrs. $7.50.

This is the final volume of a new edition of a work last issued in 1938 in two volumes. The purpose of this volume is to correlate the known facts, so far as completeness and consistency of existing information permits, about the more important alloy and special steels and their heat treatment. The usefulness of these steels for special purposes as a result of heat treatment and the use of alternate steels are discussed. The three sections of the book deal with Engineering Alloy Steels, Constructional Alloy Steels for Heat Treating, and Special Steels. Extensive bibliographies are given at the ends of chapters, and indexes of steels and subjects are included.

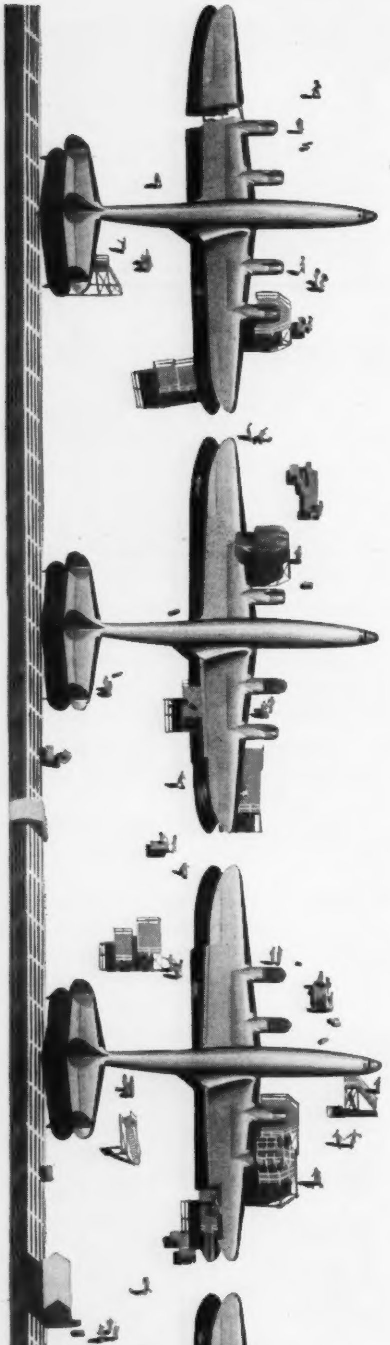
Structure and Properties of Alloys, the Application of Phase Diagrams to the Interpretation and Control of Industrial Alloy Structures. R. M. Brick and Arthur Phillips. 2nd Edition. New York, McGraw-Hill Book Company, Inc., 1949. 485 pp., figs. $6.00.

This second edition of an engineering textbook first published in 1942 is more than double the size of the first edition. It contains new chapters on magnesium alloys and on corrosion and temperature resistance alloys, and extensive additions on such topics as 75S aluminum, nonaging low-carbon steels, hardenability of steels, martempering, and elimination of retained austenite by "deep freezing." This edition contains 64 new tables, 116 new graphs, and several new micrographs, and a considerable number of new questions at the ends of chapters. The authors are professors, respectively, at the University of Pennsylvania and Yale University.

Finishes for Aluminum. Louisville, Ky., Reynolds Metals Co., Inc., 1949. 124 pp., illus.

Cathodic Protection, A Symposium by the Electrochemical Society and the National Association of Corrosion Engineers. Houston, Texas, The National Association of Corrosion Engineers, 1949. 203 pp., diagrs.

Contents: Electrochemical Principles of Cathodic Protection, by R. H. Brown and G. C. English; Characteristics and Field Use of Electrical Instruments for Corrosion Investigations and Cathodic Protection, by M. C. Miller; Characteristics of Half-Cells Used as Reference Electrodes, by Paul Fugassi; Laboratory Methods for Determining the Current Density Required for Cathodic Protection, by R. B. Mears and J. M. Bialosky; Current Required for Cathodic Protection, by N. P. Peifer; Detection, Measurement and Mitigation of Stray-Current Electrolysis, by Frank B. Fry; Detection and Measurement of Currents Other than Stray Currents, Including Magnetic Earth Currents, by Lyle R. Sheppard; Coordination of Cathodic Protective Installations to Avoid Interference with Adjacent Structures, by L. B. Nelson; Use of Rectifiers as an External Source of Protective Currents, by F. A. Waelter-



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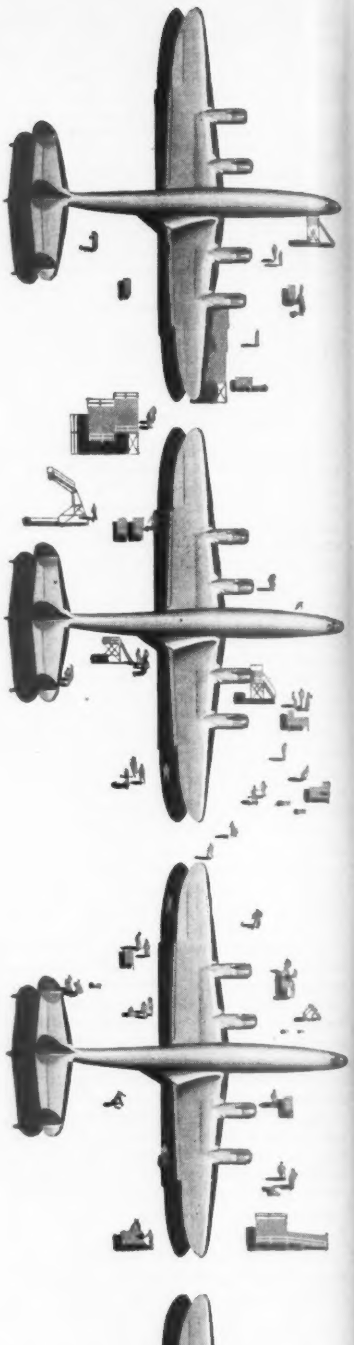
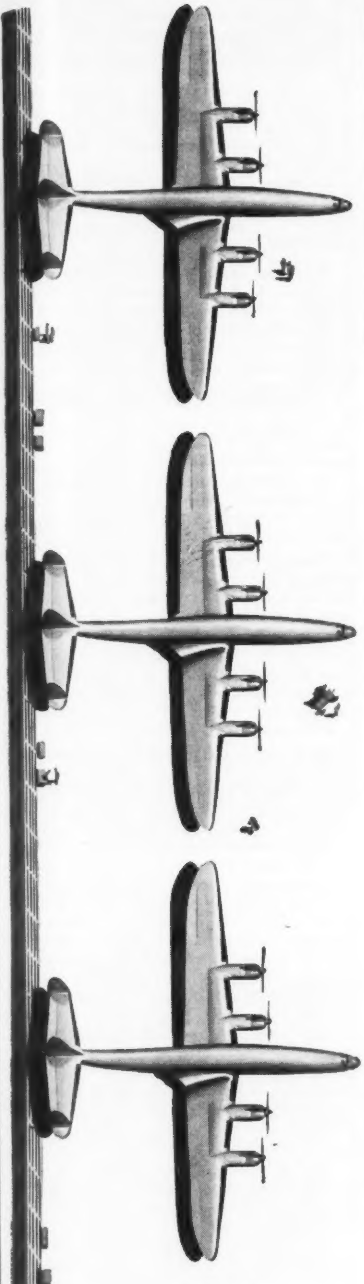




man; Use of Wind-Driven Generators as an External Source of Protective Currents, by M. L. Jacobs; Economic Factors Bearing on Application of Cathodic Protection, by D. B. Good; Locations and Materials for Anodes for Impressed Current, by Derk Holsteyn; Relative Merits of Various Cathodic Protection Current Sources, by G. R. Olson and C. W. Evans; Physical and Chemical Characteristics of Zinc Anodes, by E. A. Anderson; Current Output of Light Metal Galvanic Anodes as a Function of Soil Resistivity, by E. D. Verink, K. K. Reid and E. R. Diggins; Fundamental Characteristics of Magnesium Galvanic Anodes, by H. A. Robinson; Practical Use of Galvanic Anodes, by Hugo W. Walquist and Henry M. Fanett; Behavior of Experimental Zinc-Iron Couples Underground, by I. A. Denison and W. Romanoff; Anodic Behavior of Zinc and Aluminum-Zinc Alloys in Sea Water, by Thomas P. May, George S. Gordon, and S. Schuldiner; Corrosion and Protection of Underground Power Cables, by L. J. Gorman; Effect of Environment Characteristics on Cathodic System Design, by F. J. LeFebvre and L. P. Sudrabin; Relations Between Protective Coatings and Cathodic Protection, by Guy Corfield, and Cathodic Protection in the Control of Stress Corrosion Cracking, by High J. McDonald and James T. Waber.

Modern Plastics Encyclopedia, 1949. New York, Plastics Catalogue Corporation, 1949. 1371 pp., illus. $5.00.

This edition includes a series of articles on 27 fields of application, each with a bibliography, forming a 200-page section on "Plastics in Use." A survey of the properties of plastics, abridged from a report prepared by Battelle Memorial Institute for the Office of the Chief of Ordnance, is included in the technical data section. This report is accompanied by a list of some 300 references. Other sections deal with materials, coatings, film and sheeting, fibers and fabrics, laminates and resinwood products, engineering design, molding, extruding and casting, fabricating, finishing and assembly, and machinery and equipment. The directory section is, as usual, comprehensive and well planned. There is a bibliography of about 150 books and periodicals.

Progress in the Theory of the Physical Properties of Glass. J. M. Stevels. New York, Elsevier Publishing Co., Inc., 1948. 104 pp., diagrs. $2.00.

Following a general review of the properties of glass, the first part deals with its density discussing researches on silicate, borate, phosphate, and germanate glasses, and general rules concerning the contraction determining coefficient. The electric conductivity of glass, dielectric losses of glass, and the molecular refraction of glass are discussed in the final chapters. The compositions of the glasses discussed are given in appendixes. The results of research in Holland are mainly taken up. American and British studies are mentioned in notes.

MILITARY AVIATION

Strategic Intelligence for American World Policy. Sherman Kent. Princeton, N.J., Princeton University Press, 1949. 226 pp. $3.00.

One definition of intelligence, as discussed here, considers it as all the things which should be known in advance of a course of action. The author distinguishes between this and security intelligence, which is basically that behind the police function. The first of three parts of this book deals with the wide and varied content of intelligence. The organizational and administrative problems of central and departmental intelligence are discussed in the second part. The final part deals with intelligence work and the range of problems peculiar to it. The author is a Professor of History at Yale University, and has had several years of experience in intelligence work.

Air Power Can Disarm, A Sequel to Air Power and the Cities, 1930. J. M. Spaight. London, Air League of the British Empire, in cooperation with Sir Isaac Pitman & Sons, Ltd., 1948. 173 pp. 10*s.* 6*d.*

On the basis of an analysis of the effects of strategic bombing upon Germany and Japan, the author concludes that air power virtually disarmed them. The attacks upon cities are considered less effective toward this end than the damage done to oil and transportation targets. Air power did not end the war alone, but contributed substantially to bring Germany and Japan to the point where victory was impossible for them.

Bombing and Strategy, The Fallacy of Total War. Admiral Sir Gerald Dickens. London; Sampson, Low, Marston & Co., Ltd., 1949. 90 pp. 7*s.* 6*d.*

Admiral Dickens' discussion is concerned with future policy in the employment by England of air power, in the light of specific results of the policies followed in World War II. Strategic bombing is considered to have been a failure, partly because the required force for successful strategic bombing would have to be much larger than the force actually used. The doctrine that all combined forces should be directed toward threats to British sea power, and the doctrine of singleness of purpose are considered to have been violated by the pursuit of both strategic bombing and air protection to sea communications. The destruction of noncombatant lives is considered to be a poor investment from both the military and ethical points of view, and to be detrimental to the securing of a stable peace. Air power of the future is seen to be indispensable to sea power, without changing the fundamental nature of sea power.

Technology and International Relations. Edited by William Fielding Ogburn. Chicago, University of Chicago Press, 1949. 202 pp. $4.00.

The background for these discussions is centered upon shifts in the military ranking of the world powers, the growth of the state in size, and the movement for peace. The airplane has made congested states with numerous cities weaker and has widened the gap between strong and weak states, but has contributed an increased peacetime potential for trade, travel, and investment. Atomic energy, new mass-communications systems, and the continuing industrialization of the world are discussed in separate papers, and papers on New Techniques of War and National Policies, and Technology and World Order conclude the book.

MODEL AIRPLANES

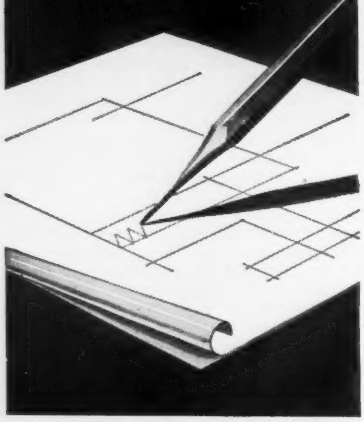
Control Line Model Aircraft, compiled by D. J. Laidlaw-Dickson and edited by D. A. Russell. Stanbridge, Bedfordshire, England, Harborough, 1949. 128 pp., illus., diagrs. 7*s.* 6*d.*

This is intended as a guide to the model builder and flyer who is not an expert, taking him from his first model, which may be made from a kit, to the elements of control line flying. Some knowledge of airplane models is assumed, but no knowledge of control line building and flying is necessary for the reader. Typical contest rules and reference tables are included in appendixes.

POWER PLANTS

Aircraft Engines of the World, 1949. Paul H Wilkinson. 225 Varick Street, New York 14, The Author, 1949. 324 pp., illus. $9.00.

In this edition of this standard international reference work, the section on jet engines and gas turbines has been moved to the front of the book. This section of 100 pages contains 40 complete specifications of main jet power plants, of which 20 are new, including the Westinghouse J 34, Pratt & Whitney J 42, Flader J 55, Armstrong Siddeley Mamba 2 and Double Mamba, Bristol Proteus and Coupled Proteus, De Havilland Goblin 3 and Ghost 45, Rolls-Royce Dart, Commonwealth Aircraft Nene, Hispano-Suiza Nene, Rateau SRA-101, S.N.E.C. M.A. ATAR 101, S.O.-C.E.M.A. TGA-1, and TGAR-1008, Svenska Flygmotor Goblin 3, and U.S.S.R. M-003 E and M-004H. The new AiResearch and Solar gas turbine auxiliary power plants are included. The section on reciprocating engines comprises 192 pages and gives 93 specifications, of which 21 are new. Each section has its separate introduction, index, and tabulations of comparative data. These tabulations cover 30 turbojets, 15 turboprops, 16 air-cooled and 13 liquid-cooled high-



powered engines, and 9 helicopter-engines. The introductions cover jet developments in 9 countries and reciprocating engine developments in 10 countries. A special index covers all reaction propelled engine specifications to be found in editions from 1945 to 1949.

Power Test Codes, 1949. Internal-Combustion Engines. (PTC 17-1949.) New York, American Society of Mechanical Engineers, 1949. 50 pp. $1.50.

This code was last revised in 1929. It is intended to present rules for tests of a commercial nature rather than research and development tests of all forms of reciprocating internal-combustion engines. The usual block tests of aircraft engines are covered by these rules, exclusive of the propeller, but not special tests covered by AN-9503a. The computation and tabulation of results of tests are included.

Internal Combustion Turbines; Lectures Sponsored by the Institution of Mechanical Engineers. New York, American Society of Mechanical Engineers, 1949, pp. 191–268, diagrs. $2.25.

These lectures are reprinted from *War Emergency Issue No. 41* of the *Proceedings of the Institution of Mechanical Engineers.* Contents: The Prospects of Land and Marine Gas Turbines, by Hayne Constant; The Part-Load Performance of Various Gas-Turbine Engine Schemes, by D. H. Mallinson and W. G. E. Lewis; The Fuel Problem in Gas Turbines, by Peter Lloyd; The Performance of Axial-Flow Turbines, by D. G. Ainley; Heat Flow in the Gas Turbine, by A. G. Smith; and Three-dimensional Flow Theories for Axial Compressors and Turbines, by A. D. S. Carter.

PRODUCTION

Principles of Magnaflux. F. B. Doane and C. E. Betz. 3rd edition. Chicago, Illinois, Magnaflux Corporation, 1948. 388 pp., figs. $5.00.

This book was last revised in 1942. This edition reflects such wartime and postwar advances as the trend to semi- and fully automatic units, and includes new material on magnetic field distribution, factors affecting the detectibility of discontinuities, examples of indication from practice, weld inspection, nonrelevant indications, and interpretation of indications and evaluation of defects. About 40 new illustrations and drawings are included.

Standard Welding Terms and Their Definitions. (A 3.0-49.) New York, American Welding Society, 1949. 50 pp., diagrs. $1.00. **Standard Master Chart of Welding Processes and Process Charts.** (A 3.1-49.) New York, American Welding Society, 1949. 5 folded charts $0.35 ($1.25 for both if purchased together).

Over 500 terms are defined in this standard with references where appropriate to 57 figures illustrating the definitions. A grouping of terms is included, which serves as a classified index to the list. The master chart lists all 37 welding processes in commercial use, which are compared in the process charts.

REFERENCE LITERATURE

Flight Instructor. 7th revised edition. Charles A. Zweng. North Hollywood, Calif., Pan American Navigation Service, 1949. 335 pp., illus., diagrs. $3.00.

The purpose of this book is to prepare instructors for their C.A.A. examinations. Preliminary chapters deal with the theory of flight, basic flight technique, instruction requirements, and sequence of maneuvers. The greatest part of the text is concerned with elementary, intermediate, and advanced maneuvers, followed by chapters on applicable C.A.A. regulations, cross-country flying, load factors, and grading standards. Typical multiple choice questions for the written examination and about 300 questions typical of those asked in the oral examination are included.

Ground Instructor Rating. 5th revised edition. Charles A. Zweng. North Hollywood, Calif., 1948. 186 pp., illus. $3.00.

The purpose of this volume is to prepare applicants for the ground instructor rating for their C.A.A. examinations. This edition includes new material on methods of teaching, in addition to the basic subjects on the airplane and aerodynamics, aircraft powerplants, air navigation, meteorology, civil air regulations, load factor problems, and weight and balance procedure. Suggestions on how to take the written examination are included, and typical multiple choice questions are given in each chapter.

HISTORY

Perchance, a Short History of British Naval Aviation. B. J. Hurren. London, Nicholson & Watson, 1949. 197 pp., illus. 10*s.* 6*d.*

The author has a background as a naval officer, an executive in the aircraft industry, and a historical writer. He has spent several years in collecting material for this history of naval flying. It is the first history devoted entirely to British naval aviation, covering the period from 1909 to the end of World War II in 1945, and it furnishes an excellent introduction to the subject.

The Royal Air Force in the World War. Vol. III, 1940–1945. Norman Macmillan. London, George G. Harrap & Co., Ltd., 1949. 276 pp., illus. 15*s.*

This volume of standard history covers operations in the Mediterranean, North Africa, the Middle East, Sicily, and Italy, including the formation at the turning point of the war of the Mediterranean Allied Air Force.

The Army Air Forces in World War II. Volume II. Europe: Torch to Pointblank, August, 1942 to December, 1943. Prepared under the editorship of Wesley Frank Craven and James Lea Cate, by Air Historical Group, United States Air Force. Chicago, University of Chicago Press, 1949. 897 pp., illus., maps. $6.00.

This second volume of a seven volume work planned to cover all the Air Force operations in World War II is composed of five parts. Section I, The North African Campaigns, begins with the crisis in the Middle East leading to commitment of an Allied force there in 1942, and ends with the surrender of the last Germans in Africa in May, 1943. Section II deals with the origins of the combined bomber offensive against Europe, including the establishment of the Antisubmarine Command late in 1943. Section III, Sicily and Southern Italy, takes up the campaigns following the Tunisian victories, dealing with the capture of Pantelleria and Sicily, and action in Italy up to the end of 1943. Section IV continues the account of the strategic bombardment of Europe and Germany, and Section V deals briefly with the final reorganization of the air forces and the establishment of the U.S. Strategic Air Forces in Europe on January 1, 1944.

The House of Goodyear. Fifty Years of Men and Industry. Hugh Allen. Cleveland, Ohio, Corday and Gross Company, 1949. 691 pp., illus. $3.00.

This edition contains over 280 more pages than that of 1943. It includes considerable new material, and has been extensively rewritten.

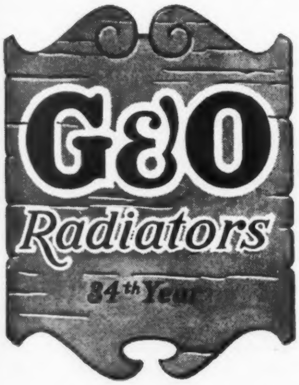
Flight To-Day and To-Morrow. H. T. Winter. London, Blackie & Son, Ltd., 1948. 255 pp., illus., diagrs. 6*s.*

Performances discussed in this review of aeronautical progress include the ascension of the Explorer II in 1933, the polar flight of the R.A.F. Lancaster Aries in 1945, and the speed flights of the Gloster Meteor IV in 1945. Technical advances discussed include the electric strain gage, direct fuel injection, Bristol air-cooled radial engines, fog dispersal, turbojet and turboprop engines, the Decca navigator, hydraulic shock absorbers, the Bristol Wayfarer and Freighter, the Bristol helicopter, plywoods, the Kodak Astrograph, and the future of high-speed air transport.

SCIENCES, GENERAL

MATHEMATICS

Introduction to the Theory of Fourier's Series and Integrals. H. S. Carslaw. 3rd edition, re-



vised and enlarged. New York, Dover Publications, Inc., 1949. 368 pp. $3.95.

This reprint includes corrections noted since the original publication of this edition in 1930. The first three chapters deal with the convergence of infinite series and integrals and the development of the idea of a limit and a function, in the light of the modern theory of real numbers. The Definite Integral is discussed next from Riemann's point of view. The related theories of series whose terms are functions of a single variable and of integrals that contain an arbitrary parameter are discussed in Chapters 5 and 6. Fourier's Series, depending on Dirichlet's integrals, are next discussed, followed by chapters on the convergence of Fourier's series and approximation curves and the Gibbs phenomenon in Fourier's series. The final chapter deals with Fourier's Integrals. Bibliographies are given at the ends of chapters.

Divergent Series. G. H. Hardy. London and New York, Oxford University Press, 1949. 396 pp. $8.00.

Professor Hardy's lectures on divergent series were almost completed at the time of his death in late 1947. Two historical chapters begin the book, and the remainder deals with methods of manipulation of these series with rigor. General theorems, special methods of summation, arithmetic means, Tauberian theorems for power series, methods of Euler and Borel, multiplication of series, Hausdorff means, Wiener's Tauberian Theorems, and the Euler-MacLaurin sum formula are discussed. Lists of books, periodicals, and definitions are included; also author and subject indexes.

Introduction to the Theory of Finite Groups. Walter Ledermann. Edinburgh and London, Oliver and Boyd; New York, Interscience Publishers, Inc., 1949. 152 pp. $3.00.

The author's aim is to present an elementary textbook on the fundamentals of the theory of finite groups for students in their second or third year. The more abstract ideas of the general theory are illustrated through the construction of particular groups, including groups arising in geometry and arithmetic. Permutation groups are discussed in some detail, but group characters are not discussed, and the theory of matrix representation is omitted, as the author feels it should not be divorced from its context in the theory of linear associative algebra. A bibliography of six books in English is included.

Analytic Geometry. Revised Edition. Charles H. Sisam. New York, Henry Holt and Co., 1949. 304 pp., diagrs. $2.40.

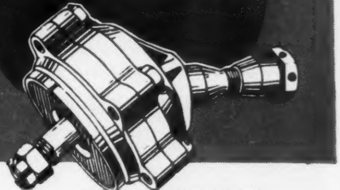
This is the first revision of a textbook published in 1936 incorporating changes as suggested by classroom experience. The exercises have been completely revised and increased in number. The author is Emeritus Professor of Mathematics at Colorado College.

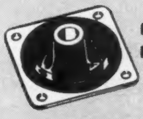
Analytic Geometry and Calculus; A Unified Treatment. Frederic H. Miller. New York, John Wiley & Sons, Inc., 1949. 658 pp., figs. $5.00.

Plane and solid analytic geometry and differential and integral calculus are correlated as a single branch of mathematical analysis in this textbook for engineering and science students. Each chapter closes with a summary of the concepts, definitions, theorems, and methods covered. Important symbols and their meanings, essential formulas, definitions and theorems from algebra, geometry and trigonometry, numerical tables, and a table of 100 integral forms are included in appendixes. There are 3,025 exercises, and answers are given to those with odd numbers. The author is a Professor and Head of the Department of Mathematics at The Cooper Union.

Partial Differential Equations in Physics. Arnold Sommerfeld. Translated by Ernst G. Straus. New York, Academic Press, Inc., 1949. 335 pp., diagrs. $5.80.

This translation of the sixth volume of Professor Sommerfeld's *Lectures on Theoretical Physics* is the first of a series of monographs and textbooks on pure and applied mathematics. Chapter I deals with Fourier series and integrals





based throughout on the method of least squares. The different types of differential equations and boundary value problems and a general introduction to Green's theorem and Green's function are next discussed. A discussion of the classic problem of heat conduction is followed by a detailed chapter on Bessel functions and spherical harmonics, including a special section of the method of reciprocal radii. The general method of eigen-functions, with applications to wave mechanics, is next taken up, and the final chapter deals in some detail with the propagation of radio waves. There is an appendix on Radio Waves on the Spherical Earth, and sets of exercises for each chapter are included.

Tables for Harmonic Synthesis, Giving the Terms of Fourier Series to One Decimal at Every Millicycle Tabulated for Coefficients 1 to 100, and Fiducial Cosine Values to Eight Decimals. J. D. H. Donnay and G. E. Hamburger. Baltimore, The Johns Hopkins University, Crystallographic Laboratory, J. D. H. Donnay, 1948. 103 unbound mimeographed pages. $10.

This table gives $10F \cos X$, for $F = 1\ (1)\ 100$ and $X = 1\ (1)\ 1{,}000$. The unit of angle, $2\pi/1{,}000$, is called a millicycle (*mC*). Since $\sin X = \cos (X + 750)$, the table also gives $10F \sin X$. In all 200,000 values are thus available, represented by 25,000 entries, 250 for each page, and one page for every value of F.

The Mathematics of Circuit Analysis. E. A. Guillemin. New York, John Wiley & Sons, Inc., 1949. 590 pp., figs. $7.50.

This is the fourth textbook in the series prepared by the Department of Electrical Engineering of the Massachusetts Institute of Technology. It is a purely mathematical discussion whose primary purpose is to stimulate interest and help prepare a background for advanced study. The first four chapters bring together into one unit, topics in advanced algebra useful in fields such as circuit analysis, vibrations, or particle dynamics, where determinants, matrices, linear transformations, and quadratic forms may be applied. The following chapter is on vector analysis leading up to a detailed chapter on functions of a complex variable. The final chapter deals with Fourier series and integrals.

Mathematics at Work. Holbrook L. Horton. New York, The Industrial Press, 1949. 700 pp., diagrs. $6.00.

This book contains "Practical applications of arithmetic, algebra, geometry, trigonometry, logarithms to the step-by-step solutions of mechanical problems, with formulas commonly used in engineering practice, standard reference tables and a concise review of basic mathematical principles." Problems are included on right- and oblique-angled triangles, tapers and angles, arcs, circles and vees, mechanics and strength of materials, and gear ratios, with a section on miscellaneous problems. Each problem is analyzed before the formulas and their derivation are given, and an example and its solution is given in each case. Approximate formulas, empirical formulas, trial and error solutions, errors and working formulas are treated separately. A section of 16 working tables is included.

An Introduction to Mathematics. A. N. Whitehead. New York and London, Oxford University Press, 1948. 191 pp., diagrs. $2.00.

This is the first American edition of this classic first published in 1911. It has been completely reset with redrawn diagrams and corrections under the direction of Professor J. H. C. Whitehead.

Introduction to Dynamics. Martin Davidson. London, Winchester Publications, Ltd., 1949. 128 pp., diagrs. 5*s.*

This textbook is designed to cover the requirements for the London University matriculation examination or the general school examinations. Knowledge of plane trigonometry is required of the reader, particularly in dealing with the parallelogram and triangle of forces and with problems on relative velocity. Problems accompany each chapter, and answers are provided.

Introduction to Statistical Mechanics. Ronald W. Gurney. New York, McGraw-Hill Book Company, Inc., 1949. 268 pp., figs. $5.00.

This is an advanced textbook designed for students of physics and chemistry. Against a background of atomic physics, the author examines the behavior of large groups of particles leading to the behavior of matter in bulk as indicated by the properties of individual atoms. The first seven chapters deal with basic principles and applications in such fields as gases and solids, imperfect gases, saturated vapor pressure, a partially dissociated gas, and solutions and alloys, especially solutions in the alpha and gamma phases of iron, leading into steel metallurgy. The final five chapters include further applications and theoretical material on classical mechanics and its use of phase space; the interaction between particles; and the Fermi-Dirac statistics. Footnote references are included throughout. The author is a Visiting Professor of Physics at The Johns Hopkins University.

Mechanics and Applied Heat. 2nd edition. S. H. Moorfield and H. H. Winstanley. London, Edward Arnold & Company, New York, Longmans, Green & Co., 1948. 324 pp., diagrs. $1.60.

This edition of a textbook first published in 1934 was undertaken principally to replace the pound-centigrade heat unit by the British Thermal Unit, which is now chiefly used in the text and examples. The gram-calorie unit is retained, however, because of its requirement by electrical engineering students. Additions and alterations have also been made in the text. The purpose of the volume is to offer a beginning course in engineering science preparing for more advanced work leading to the national certificate examination. The examples are taken largely from recent examinations.

OPTICS

Tables of Scattering Functions for Spherical Particles. (*U.S., National Bureau of Stand-*

ards, Applied Mathematics Series, No. 4.) Washington, U.S. Govt. Printing Office, 1949. 119 pp. $0.45.

These tables are based on the theory of Gustav Mie on the scattering of light, published in 1908, applied to the computation of extensive tables of Intensity Functions for both real and complex values of the index of refraction. Tabular material relating to real indices of refraction was published in 1943 as O.S.R.D. Report No. 1857. The present volume includes these tables with additional tables of scattering functions for complex indices of refraction.

PHYSICS

Ultrasonics. Benson Carlin. New York, McGraw-Hill Book Company, Inc., 1949. 270 pp., figures. $5.00.

The subject is approached as much as possible from the practical and engineering point of view. Ultrasonic waves, crystals and crystal holders, resonance and reflection, continuous and pulsed wave ultrasonic systems, ultrasonic agitation, and magnetostriction and practical considerations in the application of ultrasonics are among the topics discussed. The final chapter deals largely with applications to materials testing. Footnote references are included throughout and an index of subjects and authors is provided. The author is with the Hillyer Instrument Company, Inc.

Industrial Uses of Radioactive Materials; A Selected Bibliography. Cambridge, Mass., Arthur D. Little, Inc., 1949. 13 pp.

About 180 references are given upon applications of radioactive tracers in the specific fields of petroleum, mining and metallurgy, textiles, instruments, radiography, analysis, pharmaceuticals, and glass. General and background references, and references on radioisotope preparation and miscellaneous industrial applications are included.

Industrial Rheology and Rheological Structures. Henry Green. New York, John Wiley & Sons, Inc., 1949. 311 pp., figs. $5.50.

The author's purpose is to present a workable rheological system for the laboratory man correlating rheological with microscopical investigation. The system is based upon 10 years of experience with its development and use in the Research Laboratories of the Interchemical Corporation. It is a first attempt to present such a system in book form. Following an outline of the system, its application to laboratory measurements is taken up. The second half of the book is devoted to the particle as the basis of rheological structure and of particle groups. A bibliography of 115 references and a glossary of more than 168 terms are included, and there are author and subject indexes.

THERMODYNAMICS

Heat Transfer and Fluid Mechanics Institute, Berkeley, California, 1949. New York, American Society of Mechanical Engineers, May, 1949 278 pp., diagrs. $5.00.

Contents: Co-Current Gas-Liquid Flow—I. Flow in Horizontal Tubes, by O. P. Bergelin and Carl Gazley, Jr.; Co-Current Gas-Liquid Flow—II. Flow in Vertical Tubes, by O. P. Bergelin, P. K. Kegel, F. G. Carpenter, and Carl Gazley, Jr.; Co-Current Gas-Liquid Flow—III. Interfacial Shear and Stability, by Carl Gazley, Jr.; An Analysis of Short Length Liquid Sprays, by Martin B. Biles; Boundary Layer Effects on Spinning Spheres, by Harold Wayland and Frank G. White; Pressure Distributions from Theoretical Approximations of the Flow Pattern, by John S. McNown and En-Yun Hsu; Mixing of Parallel Flowing Streams in a Pressure Gradient, by C. K. Ferguson; A Study of Freely Expanding Inhomogeneous Jets, by W. R. Keagy and A. E. Weller; Loss Coefficients for Abrupt Changes in Flow Cross Section with Low Reynolds Number Flow in Multiple Tube Systems, by William M. Kays; Photographic Study of Bubble Formation in Heat Transfer to Subcooled Water, by Fred C. Gunther and Frank Kreith; Pressure Drop and Convective Heat Transfer with Surface Boiling at High Heat Flux; Data for Aniline, N-Butyl Alcohol and Water, by Frank Kreith and Martin Summerfield; Heat Transfer Coefficients in Beds of Moving Solids, by O. Levenspiel and J. S. Walton; Report of Progress on Measurements of Friction Coefficients, Recovery Factors and Heat Transfer Coefficients for Supersonic Flow of Air in a Pipe, by Joseph Kaye, Joseph H. Keenan, and William H. McAdams; Heat-Transfer Coefficients and Friction Factors for Air Flowing in a Tube at High Surface Temperatures, by Leroy V. Humble, Warren H. Lowdermilk, and Milton D. Grele; Interferometric Studies of Beginning Turbulence in Free and Forced Convection Boundary Layers on a Heated Plate, by Ernst R. G. Eckert; Cooling by Forcing a Fluid Through a Porous Plate in Contact with a Hot Gas Stream, by Max Jakob and I. B. Fieldhouse; Instrumentation for Measuring Temperature and Pressure of Luminous Flames of Short Duration, by O. E. Teichmann; Technique for the Optical Measurement of Turbulence in High Speed Flow, by Leslie S. G. Kovasznay; Design and Initial Operation of a Low Density Supersonic Wind Tunnel, by S. A. Schaaf, D. O. Horning, and E. D. Kane; A Method for Measuring Surface Heat Transfer Using Cyclic Temperature Variations, by J. C. Bell and E. F. Katz; Theoretical Calculation of the Diffuser Efficiency of Supersonic Wind Tunnels with Free Jet Test Section, by Rudolf Hermann; and The Impact Tube in a Viscous Compressible Gas, by T. L. Chambre and H. R. Smith.

STRUCTURES

Theory of Notch Stresses; Principles for Exact Stress Calculation. Heinz Neuber. Translated from the German for The David Taylor Model Basin, U.S. Navy, by F. A. Raven. Ann Arbor, Mich., J. W. Edwards, 1946. 181 pp., diagrs. $4.25.

Since its original publication under the title *Kerbspannungslehre*, Berlin, 1937, this book has established itself as an indispensable work on the theory of notch effects. This translation was originally published in a limited edition in 1945.

Strength of Materials. J. P. Den Hartog. New York, McGraw-Hill Book Company, Inc., 1949. 323 pp., figs. $4.00.

This text is designed for the first course in strength of materials for engineering students. Tension, Torsion, Bending, Compound Stresses, Deflections of Beams, Special Beam Problems, Cylinders and Curved Bars, The Energy Method, Buckling, and Experimental Elasticity are the chapter headings. In beam problems, the method of repeated application of cantilever formulas is emphasized in preference to the area-moment method. The Mohr's circle method is treated fully for the moments of inertia and for strains as well as stresses. The theory of the center of shear is discussed in an elementary manner, and photo-elasticity and strain gages are included in the final chapter. There are 350 problems with answers keyed to appropriate sections of the text. The author is a Professor of Mechanical Engineering at the Massachusetts Institute of Technology.

The Problem of Stick Force per g

(*Continued from page 39*)

versa), the ability to discriminate or judge pressures is adversely affected.[2]

The second predicament, that of the spiral dive, is, of course, related to the maneuvering stick forces in turning flight, and it may be equally as critical as the first. Spiral instability, which is exhibited by most airplanes that otherwise fly satisfactorily, may readily increase the chances of getting an airplane into this situation when it is flown by an untrained pilot.

In conclusion, an understanding of the problems of stick-force gradient relative to their character and magnitude is an important consideration in the design of any light airplane, the nature of which will depend ultimately on its intended use. Regardless of how adequately this problem is considered, there is little protection for pilots who insist on flying in instrument weather with little or no training or experience in this type of flying.

References

[1] Phillips, William H., *Appreciation and Prediction of Flying Qualities,* N.A.C.A. T.N. No. 1670, August, 1948.

[2] Orlansky, Jesse, *Psychological Aspects of Stick and Rudder in Aircraft,* Aeronautical Engineering Review, Vol. 8, No. 1, January, 1949.

[3] Anon, *Airplane Airworthiness—Normal, Utility, Acrobatic and Restricted Purpose Categories,* Part 03 Civil Regulations, effective December 15, 1946.

[4] Long, Lloyd L., *Effect of an Anti-Servo Tab Having Various Deflection Ratios on Elevator Stick Forces in Accelerated Flight from Flight Tests on the Model A35,* Beech Aerodynamic Report 275, Supplement I, October 27, 1948.

[5] Wells, T. A., *G's,* Air Facts, Vol. II, No. 12, December 1, 1948.

I.A.S. News

(Continued from page 13)

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Transferred to Associate Fellow Grade

Gerard, George, M. of Ae.E., Instructor in Aeronautics, Guggenheim School of Aeronautics, New York University.

Jones, Loren F., B.S. in E.E., Mgr., Market Analysis, Engineering Products Div., & Mgr. of Research Products, Radio Corp. of America.

Molloy, Richard C., S.B. in A.E., Executive Research Engineer, Research Dept., United Aircraft Corp.

Pinkel, Benjamin, B.S. in E.E., Chief, Fuels & Thermodynamics Research Div., N.A.C.A. (Cleveland).

Sandstrom, Roy J., B.S., Ae.E., Executive Chief Engineer, Bell Aircraft Corp.

Elected to MEMBER Grade

Bailey, Robert A., Asst. Project Engineer, Lockheed Aircraft Corp.

Baker, Richard H., M.M.E., Asst. Director of Labs., Naval Air Missile Test Center (Pt. Mugu).

Cole, Franklyn B., B.S. in C.E., Research Group Engineer, Controls, Lockheed Aircraft Corp.

Crawford, James V., M.S. in M.E., Administrative Engineer, AiResearch Mfg. Co.

Ellis, J. Dean, B.M.E., President & Consultant, Research & Development Industries.

English, LeRoy F., B.S. in Ae.E., Engineer, Mechanical Design; Owner & Designer, LeRoy F. English Co.

Goodman, John F., B.S.A.E., Aerodynamics Engineer, Flight Test Dept., Pilotless Plane Div., Fairchild Engine & Airplane Corp.

Greer, Ralph T., A.A., Asst. District Mgr., Sperry Gyroscope Co. Div., The Sperry Corp.

Jensen, Raymond Walter, Project Engineer, AiResearch Mfg. Co.

Johnston, Orin B., Asst. to Vice-President, Aero. Div., Minneapolis-Honeywell Regulator Co.

Lehman, William F., E.E., Hydrodynamics Engineer, Experimental Towing Tank, Stevens Institute of Technology.

Mackay, Robert Wood, Application Engineer, Aviation Section, Canadian General Electric Co., Ltd.

Nilsson, J. Erik V., M.S., Calculation Engineer, Research Dept., SAAB Aircraft Co.

Peirce, Chester, B.S., Mechanical Engineer, Guided Missiles, U.S.A.F.-Los Angeles Air Materiel Command Engineering Field Office.

Pian, Theodore H. H., Sc.D., Staff Member, Aero-Elastic & Structures Research Lab., Massachusetts Institute of Technology.

Rose, B. A., Ph.D., Department Engineer, Mechanical Research, Lockheed Aircraft Corp.

Smith, Francis A., Project Engineer, Preliminary Design, Lockheed Aircraft Corp.

Swain, Dean H., B.A., Lt. Comdr., Industrial Management Officer, Overhaul & Repair Dept., Naval Air Station (Norfolk), U.S. Navy.

Versaw, Edward F., B.S. in M.E., Research Engineer, Lockheed Aircraft Corp.

Wilson, Leonard Donald, Flight Lt. Engineering & Education Officer, R.A.F.

Transferred to MEMBER Grade

Anderson, Karl M., Engineering Designer, Douglas Aircraft Co., Inc.

Green, Leon, Jr., M.S., Research Engineer, Jet Propulsion Lab., GALCIT, California Institute of Technology.

Hovey, Robert W., M.E. (Aero.), Aerodynamics Engineer, Douglas Aircraft Co., Inc. (El Segundo).

Sawdey, Marshall D., B.S. in A.E. & M.E., Asst. Project Engineer, Bell Aircraft Corp.

Stocking, Lowell Ellsworth, Missile Power Plant Engineer, Field Test Group (Pt. Mugu), Douglas Aircraft Co., Inc.

Elected to Associate Member Grade

Blanton, David D., Hand-Book Checker & Technical Writer, Boeing Airplane Co. (Wichita).

Dutton, Roy A., Engineering Mgr., Northrop Aircraft, Inc.

Long, J. William, B.E.E., Administrative Engineer, Propeller Div., Curtiss Wright Corp.

Transferred to Associate Member Grade

Oaklander, Harold, General Director, Harold Oaklander & Assoc.

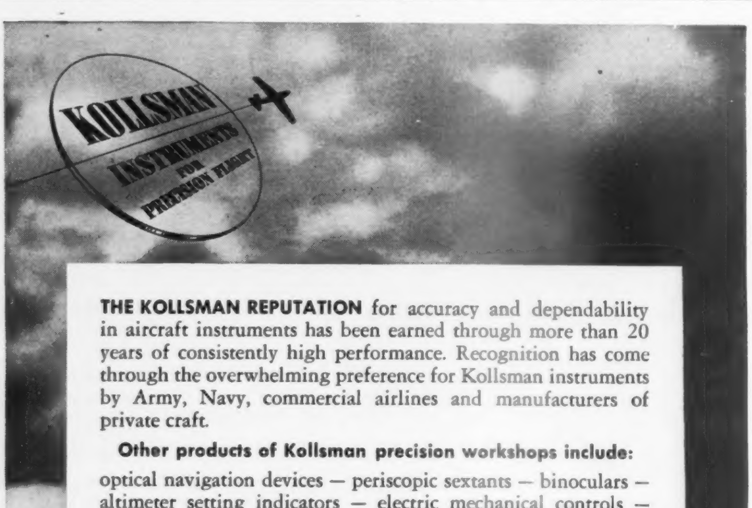
Elected to Technical Member Grade

Ellis, John Winthrop, Jr., B.S. (Aero.), Asst. Engineer, The RAND Corp.

Fisher, Gordon D., Aerodynamicist, Lockheed Aircraft Corp.

Transferred to Technical Member Grade

Adams, Mac C., M.Ae.E., Aero. Engineer, N.A.C.A. (Langley Air Force Base).



Allan, Donald George, B.A.Sc., Aircraft Design Draughtsman, A. V. Roe Canada, Ltd.

Armstrong, Alan W., B.A.Sc., Flight Officer, Aero. Engineering Officer, R.C.A.F.

Bard, Donald O., B.S. in Ae.E., Design Engineer, Marlin Rockwell Corp.

Basanese, John E.

Bedenkop, Walter L., Jr., B.S., Graduate Student, University of Illinois.

Boison, Columbus, B.M.E., Research Asst., Syracuse University.

Boulanger, Robert J., Template Maker "A," Northrop Aircraft, Inc.

Cartwright, Edwin O., Jr., B.S., Engineering Trainee, Chance Vought Aircraft Div., United Aircraft Corp.

Chung, Jung Git, B. of Ae.E.

Clancy, Frank M., Jr., B.A.E., Jr. Engineer, Flight Control Group, Piasecki Helicopter Corp.

Craig, Thomas W., A.A., Weight Analyst, Douglas Aircraft Co., Inc. (Santa Monica).

Dalin, George A., Flight Engineer, Northwest Airlines, Inc.

Davis, Donald A., B.A.Sc., Engineering Trainee, A. V. Roe Canada, Ltd.

Demko, Andrew G., B.S.M.E. (Aero.), Victor Div., Radio Corp. of America.

Drury, Lloyd L., B.S., Field Engineer, Mechanical, The California Co.

Durand, Harlan P., B.S., Research Fellow, University of Washington.

Ebersole, Francis H., B.S. in Ae.E.

Eckert, Donald H., B. of Ae.E., Mathematician "B," North American Aviation, Inc.

Elling, Richard J., B.S. in Ae.E., Production Engineer, Goodyear Aircraft Corp.

Etherington, William C., B.M.E.

Fenton, Wayne H., B.S.

Fitch, George E., Jr., B.S., Mathematician, Structures Dept., North American Aviation, Inc.

Fox, John A., B.S. in Ae.E. & B.S. in Math., Instructor in Aero. Engineering, The Pennsylvania State College.

Glew, Lester, B. of Ae.E.

Hartline, David A., B.S. in Ae.E., Jr. Engineer-Designer, East Coast Aeronautics, Inc.

Henry, John C., B.A.Sc., Student Pilot & Officer in Training, Centralia Station, R.C.A.F.

Henry, Kenneth C., B.A.Sc., Aero. Engineering Officer; Flight Lt., R.C.A.F.

Heyson, Harry H., B.Ae.E., Aero. Engineer, N.A.C.A. (Langley Air Force Base).

Holzer, Charles F., Weight Analyst, North American Aviation, Inc.

Howe, Robert, Liaison Engineer, Northrop Aero. Institute.

Hutton, Robert E., B.E., Engineer, Stress Analysis Group, Hughes Aircraft Co.

Jackson, Paul Harold, Jr., B.S. in Ae.E., Graduate Student, California Institute of Technology.

Jones, John P., B.S.

Kirby, Robert Johnson, B.S. in Ae.E.

Klein, Edward C., B.S. in Ae.E., Layout Draftsman, Chance Vought Aircraft Div., United Aircraft Corp.

Kruger, Frederick Joseph, Draftsman, North American Aviation, Inc.

Kwong, King T., Structural Designer, Endurance Metal Products.

Liu, Tung-Sheng, M.S. in Ae.E., Instructor, University of Minnesota.

Lyon, Lloyd B., B.Ae.E.

Marsanico, George A., Draftsman, Allied Process Engineers.

Marshall, Duncan C., B.A.Sc., Student Engineer, A. V. Roe Canada, Ltd.

Miller, Leland T., Weight Analyst, North American Aviation, Inc.

Moorhead, Seth B., B. of Ae.E., Engineer, Pilotless Aircraft Design Lab., Naval Air Development Station (Johnsville).

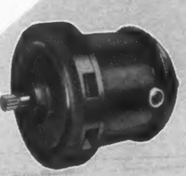
Padlog, Joseph, B.Ae.E.

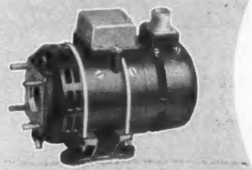
Peloubet, Raymond P., Jr., B.S. in M.E. (Aero.), Aero. Engineer P-1, Wright-Patterson Air Force Base.

Peoples, Philip L., B.S., Engineer, Boeing Airplane Co. (Seattle).

Poznik, William, M.E. (Aero.).

Prather, Joseph B., Wind Tunnel Operator, Cooperative Wind Tunnel, California Institute of Technology.





Reed, Richard E., B.S., Aero. Research Engineer, N.A.C.A. (Langley Air Force Base).

Roseman, Carl P., Draftsman "A," Hughes Aircraft Co.

Rostykus, George J., Jr., A.A., Estimator, Boeing Airplane Co.

Rubin, Arnold J., B. of Ae.E., Aero. Engineer, Wind Tunnel Research, Langley Aero. Lab., N.A.C.A.

Ruiz, Albino, Jr., Draftsman, Checking Dept., Beech Aircraft Corp.

Sauer, Robert C., B.Ae.E., Research Asst. & Graduate Student, Polytechnic Institute of Brooklyn.

Schoemaker, Andrew R., Engineering Draftsman "B," North American Aviation, Inc.

Seaton, Charles H., B.S. in Ae.E., Instructor & Research Engineer, The Pennsylvania State College.

Sells, Carl H., B. of Ae.E., Engineer, General Electric Co.

Silverman, Bernard B., B.Ae.E.

Smith, Lawrence A., B.Ae.E., Aero. Engineer P-1, N.A.C.A. (Muroc).

Stiles, Charles A., Jr., B.S.

Swerdling, Melvin, Engineering Draftsman, Lockheed Aircraft Corp.

Thompson, Gerald H.

Wagoner, Cleo B., B.S.A.E., Aero. Research Scientist, Ames Aero. Lab., N.A.C.A.

Wallace, Richard E., B.S. in Ae.E., Student & Electrician, University of Wichita.

Winter, Ralph O., B.S., Design Engineer, McDonnell Aircraft Corp.

Woodlief, Horace L., Detail Draftsman, Aerojet Engineering Corp.

Yanero, Carmen J., Jr., B.S.Ae.E., Engineering Trainee, Chance Vought Aircraft Div., United Aircraft Corp.

Zisfein, Melvin B., S.M., Aero. Engineer, Naval Aircraft Factory (Philadelphia).

Technical Sessions—Annual Summer Meeting

(*Continued from page 31*)

scheduled into or out of LaGuardia were delayed or canceled due to air traffic congestion over LaGuardia; 3,877 flights were canceled and 4,582 were delayed an average of 33 min. each. One year later, during the same 3 months, 79 per cent of all instrument weather traffic landed with no delay, and there were no canceled flights. This remarkable improvement at LaGuardia Mr. Post attributes, in a large degree, to the use of ILS.

ILS, Mr. Post admitted, has a number of limitations. One of its primary drawbacks is that only one system is presently installed at each airport, thereby limiting its really low-weather-minimum usefulness to certain wind conditions. Major airport planning calls for the eventual installation of more than one ILS. This plan will help, and the development and use of cross-wind landing gears is also expected to be beneficial.

Another problem is how can landings be made with ceilings under 200 ft. United Air Lines plans, in its DC-6 fleet, to install couplers between the radio and autopilot, thus permitting auto-approaches to at least 100-ft. minimums. The "Zero Reader," developed by Sperry, may also be useful in permitting approaches with low ceilings. High-intensity approach lights are likewise expected to be helpful in this regard. Several people, Mr. Post said, had advanced the theory that completely blind landings would not be feasible until some way is devised for correcting crab angles caused by cross wind. The castering landing gear, he thinks, is one answer to this problem.

I.A.S. National Meeting Schedule

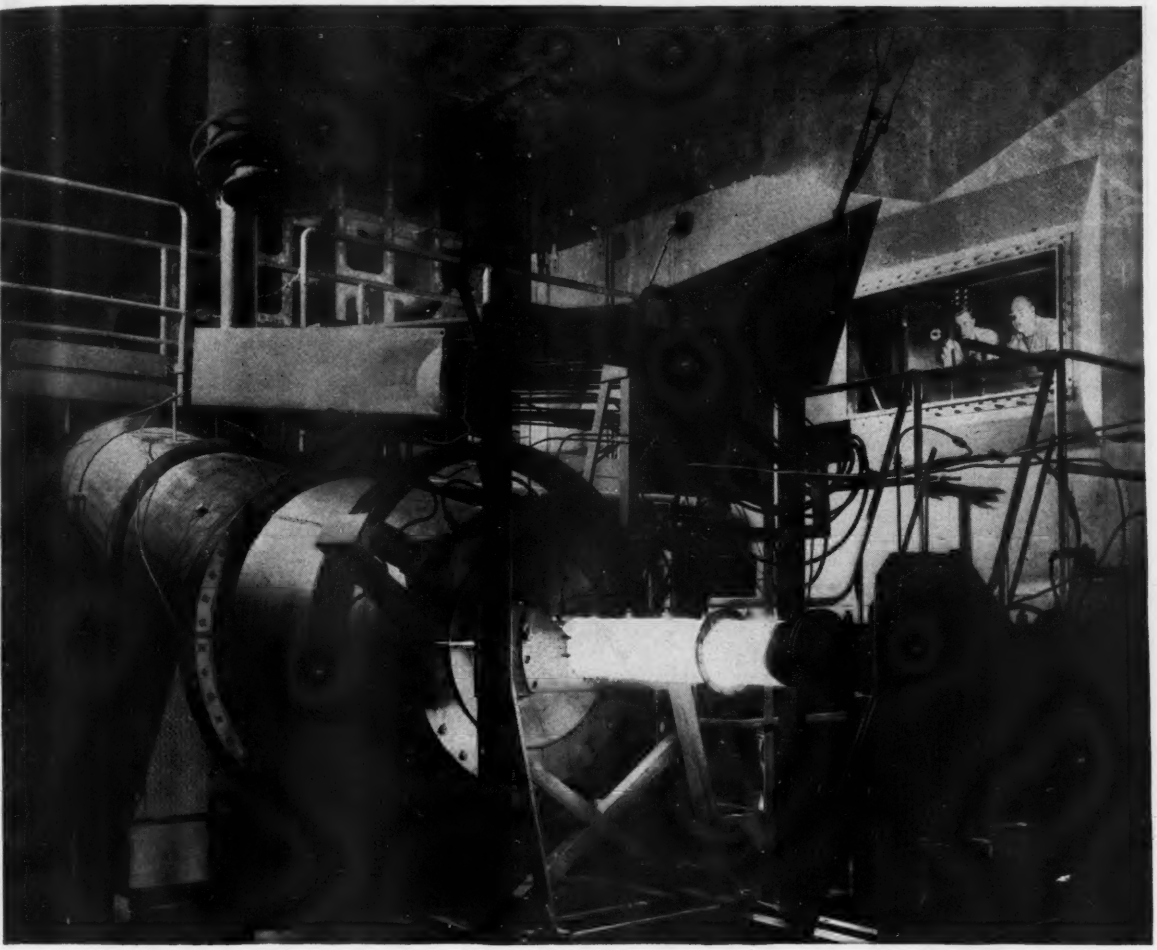
Thirteenth Wright Brothers Lecture—Washington, D.C.—December 17

Eighteenth Annual Meeting—New York—January 23–26, 1950

Members or organizations wishing to submit papers for presentation at National Meetings should send outlines or summaries to the Committee at least 3 months prior to the meeting.

All papers submitted will be considered for publication in the *Journal of the Aeronautical Sciences* or the *Aeronautical Engineering Review.*

All correspondence should be addressed to
The Meetings Committee
Institute of the Aeronautical Sciences
2 East 64th Street, New York 21, N.Y.



LOOKOUT FOR A BLOW OUT . . .

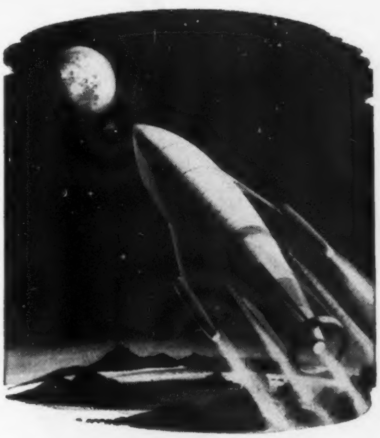
▶ These research engineers are on the "lookout" . . . for a burner blow out as they test a *white hot* scale model of a ram jet combustion chamber under development in Wright Aeronautical laboratories.

▶ It's a *precision* test . . . the test rig simulates conditions that a combustion system encounters in a ram jet operating at supersonic speed.

▶ Research like this advances the efficiency of the ram jet. It guides the engineer to the *best* combustion chamber design for eliminating flame blow out and bringing maximum combustion and operating stability to ram jets . . . the *flying furnaces* of modern aviation.

▶ To simulate high speed operation up to 2000 mph at altitudes up to 60,000 feet . . . air is forced in by huge blowers heated to 640°F to duplicate compression heat that results from ram. At this stage fuel is injected at high pressures and the fuel-air mixture ignited. The exhaust products are then evacuated at *hurricane* force by steam ejectors to produce low pressures encountered at high altitudes.

▶ Ram jet combustion research is one of many ways in which Wright Aeronautical is conducting the development of future type power plants to make Wright aircraft engines — *great today* — *even greater tomorrow.*



POWER FOR AIR PROGRESS

WRIGHT Aeronautical Corporation • Wood-Ridge, New Jersey

A DIVISION OF
CURTISS WRIGHT
FIRST IN FLIGHT

Main rotor drive built by Foote Bros. for use on Piasecki Helicopters

Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

WANTED

Engineers—The following vacancies exist at the recently established Naval Aeronautical Rocket Laboratory: Aeronautical Engineers—P-1 through P-6, $2,974.80 through $7,432.20. Electronics Engineers—P-2 through P-4, $3,727.-20 through $5,232. Chemists—P-3 through P-5, $4,479.60 through $6,235.20. Chemical Engineers—P-3, $4,479.60. Physicist—P-4, $5,232. Assignments include testing, evaluation, research, and development of liquid-propellant rocket engines. Applicants must have experience and/or training in the construction, operation, and performance of rocket engines. Both staff and project engineer positions are open. Address replies, enclosing completed copy of Civil Service Application Form 57 (obtainable at your Local Post Office), to Donald K. Holster, Personnel Officer, U.S. Naval Aeronautical Rocket Laboratory, Lake Denmark, Dover, N. J.

Aerodynamicists, Senior—For advanced problems in aerodynamics of airplanes and missiles. Inquiry should include comprehensive experience résumé. Address: Manager, Engineering Personnel, Bell Aircraft Corporation, P.O. Box 1, Buffalo 5, N. Y.

Assistant or Associate Professor—To teach undergraduate and graduate aerodynamics, preliminary design, and allied courses. Prefer man with advanced degree in aeronautical engineering and practical experience in aerodynamics or design. Salary dependent upon qualifications. Aeronautical Engineering Department, University of Kansas, Lawrence, Kan.

Airmen and Technical Personnel—Positions open in West Coast scheduled helicopter operation. **Airmen**—flight, administrative, and technical research, with or without helicopter training. Multiengined time required. **Technical**—maintenance, radio, engineering, and inspection. Power-plant and machining background important. Employment contingent upon comprehensive training program. Apply by mail only to Los Angeles Airways, Inc., 5901 West Imperial Highway, Los Angeles 45, Calif.

Aeronautical Design Engineer—For production work on the B-47 Jet bomber and modification of B-29 and B-50 Bombers. Graduate engineers, 5 years or more of heavy aircraft design experience. Direct replies to Engineering Personnel Representative, Boeing Airplane Company, Wichita Division, Wichita 1, Kan.

Structures Engineer, Senior—For advanced problems in load criteria, design, and analysis. Inquiry should include comprehensive experience résumé. Address: Manager, Engineering Personnel, Bell Aircraft Corporation, P. O. Box 1, Buffalo 5, N. Y.

37. Development Engineer—To make studies of highly technical products and manufacturing operations on a consulting basis. Excellent opportunities for capable engineer experienced in design and development of precision metal equipment. Should possess M.E.—Aero. or Physics degree; graduate work preferred. Require 3 to 5 years' industrial experience and a sound knowledge of production and administrative problems.

30. Aircraft Division Manager—To take charge of Engineering and Sales with a manufacturer of aviation equipment. Must be thoroughly experienced in design and performance of military aircraft and must have wide knowledge of the aircraft industry, as well as the armed forces. Only men with a proved record in the design and marketing of aircraft equipment will be considered.

29. Flight Test Instrumentation Engineer—To prepare instrumentation programs, guide procurement, design special equipment, supervise installation and maintenance of testing equipment of experimental aircraft. Broad experience including mechanical, electric, electronic, and photographic data recording desired. Inquiry should include education and experience summary. Location—Southern California.

28. Flight Test Engineer—To prepare general testing programs, detailed test outlines, and summary reports and to coordinate all aspects of flight-test programs on experimental aircraft. Will fly as observer during engineering testing. Experience with both Air Force and C.A.A. testing desirable. Inquiry should include education and experience summary. Location—Southern California.

23. Sales Engineer—Age 30–40. Aeronautical Engineering Degree. At least 5 years' sales experience on aeronautical instruments and familiar with thermocouples, electrical bridges, temperature sensing bulbs and indicators, fire detectors, relays, aircraft power supply, Ohm's law, and direct current. Neat appearance and progressive. Salary $5,000 to $6,000. Submit résumé for consideration.

20. Project Engineer—A well-paid permanent job with an excellent future in a growing company. Challenging, varied, and interesting work. Freedom to demonstrate skill, initiative, imagination. Congenial working conditions in a medium-sized organization. Located 200 miles from New York City, offering good living conditions and excellent recreational facilities. Qualifications: Thorough experience and proved ability to supervise design and development of complex electronic and electromechanical devices. Complete technical competence in fields of servos, analogue computers, instrumentation, small mechanism design, etc. Flight training, other aviation background, or a basic knowledge of principles of flight. Electrical engineering (electronics) education—advanced degree preferred. Ability to supervise and work with others. Minimum of 5 years' experience in responsible design and development jobs. Speed, imagination, initiative, and sufficient drive to get a job done within strict time limitations. Ability to inspire others to produce design and development work within rigid schedules. Engineers who possess the qualifications we need are invited to submit complete résumés of training, past experience, salaries earned, and salary expected.

969. Professor of Aerodynamics—To handle senior and graduate work in aerodynamics. Should have outstanding theoretical ability plus practical wind-tunnel experience in both subsonic and supersonic speeds. Position with one of the Big Nine Midwest Universities. Advanced degrees necessary.

968. Associate or Full Professor—Now permanent position available with leading midwestern state university to teach and develop courses in the general field of airplane dynamics, such as vibrations, flutter, aeroelasticity, etc., and to direct graduate research in these fields. Advanced degrees with practical industrial experience necessary. Attractive salary. Effective September 1, 1949.

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

964. Assistant Professor of Aeronautical Engineering—Equipment in particular to teach theory of elasticity of the graduate level. Duties begin September, 1949. Location Philadelphia. Apply giving education, teaching, and other experience, plus references and small photograph.

AVAILABLE

43. Junior Engineer—1949 graduate, B.A.E., New York University. Married, one child. Desires to obtain a position with an aircraft company. Prefers work related to design. Location open.

42. Powerplant Design and Development Supervision—B.S. in A.E. Last $6^1/_2$ years, supervising complete installation of large reciprocating and turbine power plants, including design, fabrication, and test. Excellent engine performance background. Direction of 100 engineers and shop personnel, including organizational and administrative work. Responsible for cost estimates, budget control, and execution of military contracts. Four years as field engineering representative for major engine manufacturer contacting all air-frame companies. Four years of general shop equipment and machinery engineering, including 1 year machine design drafting. Age 36, married. Location open. Available on 30-day notice.

41. Pilot—Aeronautical Engineer—B.S.A.E., Oregon State College. Six thousand five hundred hours flying multiengined equipment. Past 3 years with China National Aviation Corporation in Shanghai, transport and engineering test. Previous $5^1/_2$ years, Navy Patrol Plane Pilot. United States instrument and commercial certificates, Chinese A.T.R.; extensive actual instrument experience. Age 30, married, three children. Prefers West Coast; engineering test pilot placement.

40. Aeronautical Engineer—Graduate. Eight years' experience with leading aircraft manufacturers. Several years spent in the weight control section as a Group Leader on high-performance aircraft. Senior Layout Draftsman in Power Plant Group. Recent years spent in the design and development of sub- and supersonic pilotless aircraft. Desires position as Layout Draftsman on initial design requiring initiative, resourcefulness, new ideas, and background. East Coast preferred.

39. Layout Draftsman—Five years' experience in aircraft construction; age 34. Desires position with company located in Eastern States.

38. Aeronautical Engineer—Age 24, single. Graduate of New York University, June, 1949. Interested primarily in stress analysis. Location open.

35. Aerodynamicist—M.S. in A.E.; B.S. in M.E.; B.S. in A.E. One and one-half years' experience in design of axial-flow compressors and research supervision and analysis with large East Coast engine manufacturer. Present position highly satisfactory, but housing situation intolerable. Desires research and design position in field of fluid dynamics, preferably in Middle West. Will consider teaching. Age 27, married.

34. Engineer—M.S. in M.E. Fourteen years' experience in all phases of engineering work. Three years with heavy industry, six years with

aircraft, and five years with aircraft engines (jet and gas turbines). Thoroughly familiar with stress, vibration, aerodynamics, thermodynamics, design, and administration. Experienced in setting up engineering organizations from a small group to a complete department. Willing and accustomed to assume responsibility. Desires responsible position with an organization requiring advanced thinking. Prefers gas-turbine field. Location open.

33. **Aeronautical Engineer**—Thermodynamicist, Aerodynamicist. Fifteen years' practical and engineering background. Studying for Master's Degree in M.E. Eight years' mechanical background including shop, inspection, instruments, laboratory, and test work. Two years' supervision; 2 years' mechanical design and drafting; 3 years' research in guided missiles, study and design of cabin air-cooling systems, investigations, proposals, and report writing. Will consider other fields of engineering. Prefers West Coast. Will travel if necessary.

32. **Production Design Engineer**—B.S., University of Illinois. Twelve years' experience with leading airplane manufacturer, including 1 year production planning, 2 years chief cost estimator, 1 year superintendent of master scheduling, and 8 years structural design as assistant project engineer and senior design engineer. Excellent organizer, supervisor, and administrator. Married; Age 35. Desires position as production designer or administrative assistant in aircraft or allied field.

31. **Project Engineer**—B.S.A.E., M.I.T. Licensed Professional Engineer (N.Y.). Two years' graduate study in electrical engineering. Age 36; single; 14 years' experience of responsible design, development, and proposal work on pressure and gyroscopic devices, computers, and servomechanisms. Complete résumé on request. Desires responsible position with progressive organization engaged in development work on aircraft projects.

27. **Aeronautical and Mechanical Engineer**—B.S.M.E. Registered Aero. E. (Ohio). Two years' preliminary aircraft power plant and equipment installation design. Four years' military aircraft background—sub-depot supervision, technical inspection, modification, engineering drafting, and flight test. Familiar with research—design of rocket motors and jet engines. Exceptional ability in Mechanical Design. Age 32; single; available immediately, and open to other fields of engineering, preferably in the Eastern Area.

26. **Model Specialist**—Precision wind-tunnel airplane model builder; also all types of experimental machinist work done. Facilities for private contract work.

25. **Contract Administrator—Administrative Engineer**—Graduate engineer with 23 years' experience in the aviation industry covering aircraft and engine manufacturing and active duty during World War II in the Bureau of Aeronautics. Positions held have included responsible duties in engineering, financial, and administrative work, in most of which there was frequent contact with Government agencies, United States and foreign engineers, and technicians. Most recently, General Manager of a Research and Development contract coordinating opinions of authorities through aviation and allied sciences.

24. **Power-Plant Engineer**—M.E. and M.S., Stevens Tech. Licensed Professional Engineer. Fifteen years' experience in development of large air-cooled aircraft engines, including extensive staff and committee work, overseas experience, languages. Some lecturing and graduate-school teaching on aircraft power plants. East Coast resident.

19. **Aviation Executive**—Specialist with 16 years' aviation experience, domestic and abroad, air lines and manufacturers. Extensive background includes technical, operating, accounting, sales and publicity experience; many years in executive position with top consulting firm handling special research on air-lines' and manufacturers' problems. Good command of foreign languages; widely acquainted in aviation circles. Age 33; married; Southern California. Desires administrative position with air line or in aviation industry.

17. **Aeronautical Engineer**—B.S. Aero. E., Tri-State College, March, 1949, Graduate. Fifteen years in the aircraft field. Five years in the Air Corps as a technical inspector for all aircraft. Machine and Laboratory experience. Desires position in aircraft field in design, drafting, stress analysis, laboratory testing, selling, and maintenance. Age 35; married; available immediately.

16. **Aeronautical Engineer—Pilot**—B.S.A.E.; commercial pilot, single- and multiengined land, instrument, and instructor ratings; Air Force Technical training in aircraft maintenance engineering. Seven years' experience, including aircraft maintenance, service, modification and flight-test engineering and passenger ferry, instruction, and test piloting.

15. **Manufacturing Executive**—Desires position with East Coast Manufacturer. Twenty years' aircraft and allied manufacturing and engineering experience, both Europe and United States.

14. **Aeronautical Engineer—Teacher**—Ten years' experience teaching aerodynamics and allied subjects. Two years with Government agency as aerodynamicist. At present engaged in aerodynamic design of supersonic wind tunnels. Desires position that requires independent research and development on problems in supersonic, including wind-tunnel design. Location in South or West Coast preferred.

13. **Development Engineer**—B.S. in M.E., age 30, married. Ten years' progressive experience—aircraft power plants, fuel metering equipment, power controls, and accessories. Past 3 years, Assistant Project Engineer on turboprop and turbojet programs, including flight-test participation. Previous positions include Assistant Chief Inspector, Supervisor of Carburetor Test Laboratory, and Test Engineer. Desires engineering position involving experimental research or product development. Eastern States preferred.

12. **Aeronautical Executive**—Twenty years' experience, with exceptional knowledge of the aircraft and related industries. His promotional and administrative "know-how" and his ability to get things done should make him a valuable asset to an aircraft manufacturer, accessory manufacturer, or air line in general management work, particularly in connection with sales or contract development, public relations, industry relations, or Government relations. In recent position as an officer of a highly regarded national aeronautical organization, has contributed greatly to its phenomenally rapid growth over the last $8^1/_2$ years. Has voluntarily negotiated his separation with his coofficers and board of directors in order to seek a more challenging opportunity where he can apply his talents to still greater productiveness. In excellent health, has traveled widely throughout the country, and enjoys extensive contacts with the leaders in industry and in important Government circles.

11. **European Professor of Aeronautical and Mechanical Engineering**—Experience in airplane design in industry, in wind-tunnel work in research institute, and in teaching mechanics, aerodynamics, and airplane structures; would accept Assistant Professorship as first position in U.S. Spent 6 months at California Institute of Technology earlier on fellowship.

10. **Research Associate**—Ph.D. in Applied Mechanics, June, 1949, with 11 years' industrial experience in analysis, design, and production; 3 years' part-time teaching and analytical and experimental research in jet propulsion, compressible flow, and airplane structures. Desires Associate Pr fessorship with research possibilities.

999. **Public Relations Counsel**—Wishes to handle public relations and representation work for aviation organization in Utica, N.Y., and vicinity. Many years' experience in civic affairs, publicity, and promotion. Former Rehabilitation Chairman of the N.Y. State Veterans of World War II. Aircraft overhaul experience in Navy, Air Force, and Coast Guard for 9 years. Fifteen years' experience in local public relations work.

998. **Administrative Assistant** or **Aeronautical Engineer**—Bachelor Aeronautical Engineering, Georgia Tech. 1946, and Master of Business Administration, Cornell University, 1949. Age 23; married. One year as research engineer with N.A.C.A., including tunnel operation and technical report writing. General administrative experience as Navy Ensign. Available immediately.

997. **Engineer—Pilot**—B.S.M.E. (Aeronautical Major), Purdue. Registered M.E. (California). Resident Los Angeles 11 years. Thirteen years' experience, 5 years in aircraft. Naval pilot, 4 years. Represent Eastern manufacturer in Southern California. Salary or commission.

995. **Engineering Teacher**—M.S. in Mathematics (physics minor); B.S. in Mechanical Engineering (structures option); B.S. in Education. Six years' teaching experience in thermodynamics, hydraulics, hydraulics laboratory, strength of materials, applied mechanics (statics and dynamics), aircraft stress analysis, and engineering physics. Three years with major airplane company in mechanical equipment unit and stress analysis unit. Good progress in work and studies. Phi Kappa Phi while earning engineering degree. Desires teaching position in a progressive college or university. Perfers teaching any of the above. Courses on indeterminate structures, refrigeration, or internal combustion engines. Will locate anywhere but prefers the Western states, Texas, or Florida. Housing essential. A detailed outline of education and experience will be sent upon request.

970. **Manufacturers' Representative**—Aeronautical Engineer, M.S., Ae.E., California Institute of Technology; 18 years' experience in the Naval Aeronautical Organization. Technical, operation, and administrative, including $2^1/_2$ years in the Bureau of Aeronautics and over 3 years in the Office of Chief of Naval Operations. Familiar with Government contract procedures, specifications, and requirements. Retired in 1947, with senior naval rank, at age of 45, and living in Washington, D.C., area. Desires to handle Washington representation for reliable company in the aviation industry.

Changes of Address

Since the Post Office Department does not as a rule forward magazines to forwarding addresses, it is important that the Institute be notified of changes in address 30 days in advance of publishing date to ensure receipt of every issue of the *Journal and Review*.

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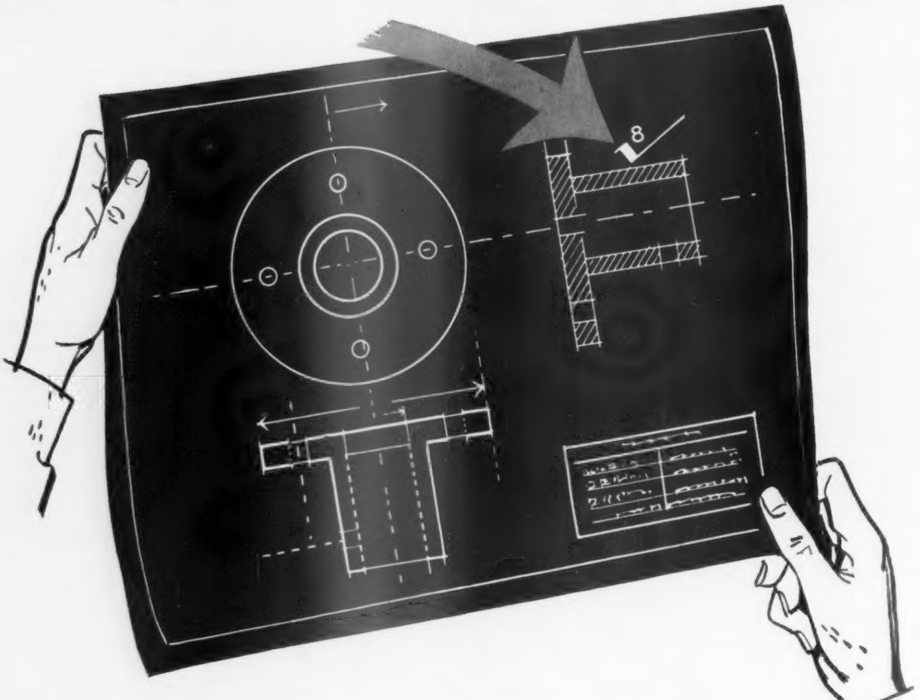
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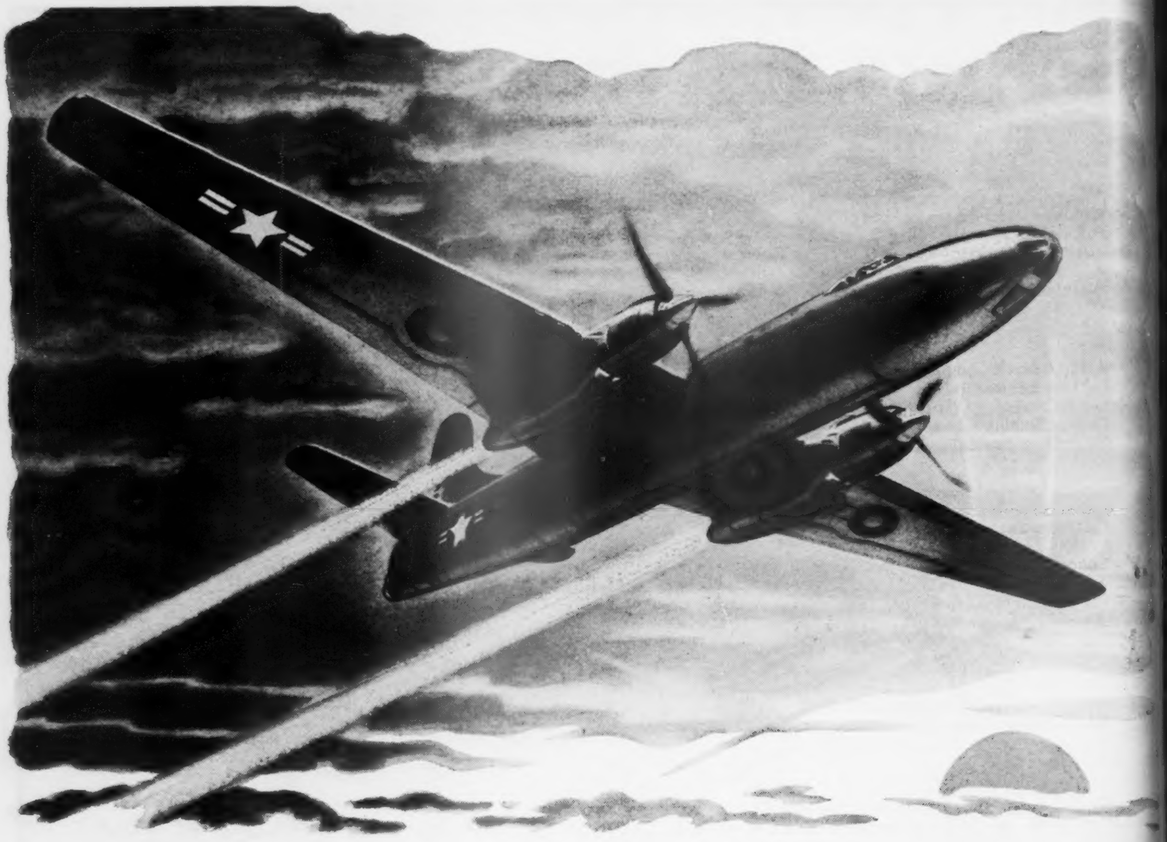

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